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ANNIVERSARY REPORT

1921 - 1946

TWENTY - FIVE YEARS OF FOREST RESEARCH

at the

Appalachian Forest Experiment Station

FOREST SERVICE

MANAGEMENT
COLLEGE
COLORADO

U. S. Department of Agriculture

Southeastern Forest Experiment Station
Asheville, North Carolina

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ANNIVERSARY REPORT 1921-1946

Twenty-five Years of Forest Research in the Southern Appalachians

INTRODUCTION

The federal forest experiment stations in the United States exist primarily for the purpose of discovering ways and means of growing more valuable timber faster. This information is for the use of managers of the world's greatest system of national forests, for timber owners, farmers, and anyone else who can and will use it. Over the years the stations have expanded to supplement timber management studies with associated work on the relation of forests to stream flow; with the Forest Survey, which measures the national, state, and local forest resource; with woodland grazing research; with a Forest Utilization Service which serves as a liaison between the famous Forest Products Laboratory at Madison, Wisconsin, and the nation's wood-using industries. Side by side with these activities go the cooperative work on tree diseases and insects, by scientists of the United States Department of Agriculture's Bureau of Plant Industry, Soils and Agricultural Engineering and the Bureau of Entomology and Plant Quarantine; work on forest wildlife under the Fish and Wildlife Service; the U.S. Weather Bureau's meteorology studies and weather predictions, vital to modern forest fire fighting and detection; also direct cooperation on specific projects with the State agricultural experiment stations, timberland owners and industries and other forestry agencies.

One of the first of the modern regional stations, the Appalachian (now Southeastern) Forest Experiment Station celebrated its Silver Anniversary on July 1, 1946. What are the accomplishments of the Station and its cooperators? How much has forest science advanced as a result of its existence? This report is an attempt at an objective summary, an account of stewardship over a quarter-century of service.

Only the highlights of progress and accomplishment will be presented in this portion. A more detailed description for each major field forms the latter half of this report.

Historical Background

Although research was one of the initial federal activities and had long been a prominent element in state and federal forestry programs, establishment of the Appalachian and other regional forest research stations in the twenties was primarily the result of two developments.

First, a growing appreciation that lack of knowledge was a major obstacle to the proper management of American forests as a permanent crop. With this went a conviction that American forestry must formulate its own techniques independently of European traditions and practices. Second, a rising interest in public aids to private forest land owners and the forest industries as a necessary step in correcting a deteriorating forest situation.

The first World War had marked the end of an era, a pioneer period crammed with the initial organization of state and federal forest services, the beginning and development of forest education, the very formulation of a profession of forestry. The most conspicuous professional task had been the organization of a great national forest system covering as early as 1911 some 170 million acres in 21 states and territories. By 1921 substantial forward strides had been made in the job of protecting, developing, and applying forest management principles to this immense area of wild land.

The time was ripe to turn to the development of a national forest policy with special attention to the problems of private ownership. A re-examination of the forest situation at the end of World War I indicated steady deterioration in forest growing stocks, both in quantity and quality. The ensuing controversy over what would constitute an adequate national forest policy and program, still actively raging, contained a challenge to industrial and other private owners to adopt sound forestry principles in the management of their lands, with many believing even in that day that public regulation of private cutting was inevitable.

Regardless of other effects, the controversy was undoubtedly helpful in focusing public attention on public aids to private forestry. Provision was made for increased federal cooperation in fire protection and planting, in furnishing advice and guidance to private owners, and in providing more adequately for research. The Appalachian Station was the direct result of such interest.

A broad attack on the forest production problems of the Appalachian region was contemplated. Two great handicaps faced the researchers. Although the program was aimed at supplying information on how to grow timber as a crop, without distinction as to class of owner, public or private, large or small, the Station had essentially only one customer, the national forest organization. Only a handful of private owners at best were interested in the possibilities of managing forest land for sustained production. In addition, there was an enormous job to be done with few men and little money. The new Station's territory covered some 120 million acres. It included all or major protions of at least seven broad forest types. The problems of this great area were to be attacked by a staff of four technicians (Frothingham, Korstian, McCarthy, and Haasis) and one clerk (Josephine Laxton) with an annual allotment of $17,300.

EARLY ACCOMPLISHMENT 1921-1926

The new Station staff, small, compact, and well-trained, went about its task with enthusiasm and skill. The initial program, partly exploratory, covered forest types as diverse as the spruce-fir stands of the loftiest peaks and ridges and the white-cedar forests of the coastal swamps, and research fields as varied as planting, natural regeneration, forest grazing, and fire damage.

In spite of diffuse activity, the early work of the Station was highly productive. Authoritative data were presented on the quantity, character, and growth of regeneration and residual trees on cut-over upland hardwood lands, and recommendations made on the basis of the best information then available as to how such forests should be protected, harvested and rehabilitated, both in terms of the minimum practices necessary to keep the land productive and the measures necessary to produce full timber crops (Frothingham: USDA Tech. Bull. No. 250). A similar though less elaborate study of spruce-fir stands showed the need for planting if cut-over and burned lands were to remain productive (Korstian: Ecological Monographs Vol. 7). Two comprehensive bulletins (Korstian and Brush: USDA Bull. No. 251; and McCarthy: USDA Bull. No. 356) analyzed new work and summed up available knowledge on seeding, growth management, and uses for two important regional species, Atlantic (southern) white-cedar and yellow-poplar. The ecological factors controlling germination and early survival of the better oaks were examined, and the practices affecting optimum seeding and seed bed conditions for this important group (chiefly measures to insure a loose friable soil and a favorable leaf litter) were outlined (Korstian: Yale School of Forestry Bull. No. 19). The effect of chestnut blight on eastern hardwood forests was determined, the resulting information showing the general good replacement of this species with other valuable hardwoods (Korstian and Stickel: USDA Misc. Circ. No. 100). An analytical examination of the Biltmore plantations, one of the earliest large-scale reforestation projects in the region, confirmed the difficulty of planting hardwoods on most former hardwood sites and indicated the greater chances of success with native conifers such as northern white pine (Haasis: USDA Misc. Pub. No. 61). Although formal publication of most of these studies was materially delayed, the fact-gathering and basic analysis was done in the early years.

In addition, a good start was made in the field of forest protection. In forestry entomology improved control practices were developed for the southern pine beetle, based on a better understanding of the ecology of this dangerous enemy of southern pines. More was learned about the tree mortality caused by fire, as well as fire's damaging effect on stand growth and composition. One interesting aspect here was the repeated emphasis given by McCarthy to the close relationship existing in eastern deciduous forests between weather and fire occurrence and spread, leading to the establishment of a fire weather forecasting unit, now one of the keystones of forest protection services. In forest pathology, work was concentrated on the chestnut blight, then recognized as beyond control, and estimates made as to its rate of spread and as to how long the dead trees would remain useful for tannin extraction and pulpwood.

Some of this knowledge was immediately applicable. Information on the durability and tannin retention of dead chestnut was used in scheduling harvesting operations for this species and the amortization of the extract plants. Researchers said the chestnut supply would last approximately 30 years and the soundness of their estimates is best evidenced by the continued existence and operation of most of the tannin-extract plants. The chestnut-replacement study stilled the advocates of immediate planting of blight infected chestnut stands by giving clear, authoritative proof of the ability of these stands, though hard hit by the loss of the versatile and rapid-growing chestnut, to reproduce satisfactorily to other desirable hardwood species. The Biltmore plantation work encouraged the planting of conifers rather than native hardwoods, at least pending further planting research.

Other branches of the Station's work had less immediate application. Indeed the bulk of effort was devoted to a systematic collection of the basic information upon which good forest management would ultimately have to be based.

The cooperative character of the work is worth emphasizing. Good examples are the whitecedar study carried out in cooperation with several state agencies, the oak seeding study in cooperation with the Yale School of Forestry, and the tannin retention study in cooperation with representatives of the extract industries. All represent a deliberate and successful effort on the part of the Station to enlist outside aid and spread its meager technical resources as far as possible over a multitude of problems.

THE MIDDLE YEARS 1927-1941

Upland Hardwood Research

Though the early program had been broad, most of the work had been concentrated on various aspects of forest land management in the mountainous portion of the Station's territory. Here lay the remnants of a complex hardwood forest repeatedly cut or culled-over and burned in more than a century of settlement. To this destructive process was added the devastation of the chestnut blight killing a valuable species constituting 30 to 40 percent of the volume of the original forest.

The main problem, therefore, was one of rehabilitating an abused and deteriorated forest containing a total of some 120 native tree species with over 40 of commercial importance. The Station had made a good beginning by furnishing better data on the quantity and quality of young growth on cut-over areas, the effect of fire on regeneration and decay and on similar basic silvical and silvicultural matters, but the recommended improvement and harvesting practices had been necessarily very general. What the practitioner needed was a more specific prescription of just what species to favor, how they would respond to release, what kinds of cutting to use with various forest conditions, what really constituted a good seed tree, and how many should be left and at what spacing. Because of the nature of the forest, the problems of the mountain hardwood region were understandably complex and numerous. Even today, much remains to be done. But a steady stream of bulletins, articles, and technical notes during the middle years indicated the activity under way in various fields.

Silviculture

One important contribution in the field of silviculture was the formulation of measures for stand improvement in southern Appalachian forests (E.C.W. Forestry Publication No. 1), used as a basis for stand treatment by CCC crews and relief labor on many thousands of acres during the great depression of the 1930's. Although the specific practices recommended in this bulletin were based on fragmentary and scattered data, a critical examination of treated areas some years later by a Committee of the Society of American Foresters showed that with some minor exceptions they had accomplished a needed silvicultural improvement.

The need stimulated much additional work on stand improvement, probably the most important problem in the mountain section. Forest pathology clarified materially our knowledge of the cause and occurrence of butt rot and other diseases in sprout forests. Fire scars were shown to be by far the greatest single avenue for butt rot in hardwoods, with a possible reduction of average losses from 15 to 1 percent of stand volume by fire elimination (Hepting and Hedgecock: USDA Circ. 570). Roth and Sleeth (USDA Tech. Bull. No. 684) prescribed cultural methods for minimizing decay in unburned stands, chiefly by cutting companion sprouts before 15 years, favoring low origin sprouts and cutting companion stems only when under 3 inches d.b.h. Eradication of cankers, on which much effort had been spent, was shown to be of little value with the two important hardwood diseases, Nectria and Strumella, since eradication is unnecessary with Nectria and ineffective with Strumella. Other work strengthened our knowledge of how to improve the composition of existing young stands, especially on how to weed young hardwood stands. Better methods were developed in releasing valuable individual or "crop" trees from overhead and side competition, in thinning even-aged hardwood stands, and in the pruning and liberation of white pine. The Station staff now believes that a sound technical basis has been laid for stand improvement measures. A new bulletin on this subject is forthcoming.

During the middle period considerable effort also went into studies of harvest cutting methods--methods that would be practical of application yet leave the forest in shape for regeneration and rapid growth. At the same time considerable information was gathered on the growth and recovery of residual trees after release. As part of the investigations on reproduction following cutting in the major types, seed production characteristics of oaks were determined. This information was useful later in the formulation of specific cutting practice guides.

The development of forest management on the national forests called for improved volume tables, converting factors, and other information early in the period. Later, increasing interest in farm woodland management made the development of local volume tables imperative. Several series of such tables were developed for all of the important mountain species, finally supplemented by the "form-class" table which permits ready local estimation of tree volumes on a sounder basis than ever before.

Forest Protection

During the middle period forest entomology continued to improve knowledge of the life history and ecology of important southern forest insects and the practical steps that could be taken to minimize resulting damage. Among other work in cooperation with the Appalachian Station (though also investigated elsewhere) were (1) the ecology and control of the southern pine beetle, (2) similar work on the turpentine borer, (3) the use of sprays and tree injections to kill bark beetles and preserve wood, (4) control measures for termites, and (5) the biology and control of white grubs in nurseries.

The work on the southern pine beetle, Dendroctonus frontalis, included one very interesting development: the discovery of the role played by the bluestain fungi and yeasts, the spores of which are introduced into the tree under favorable conditions by the bark beetles. The rapid death of a tree following bark beetle attack was found attributable to the bluestain rather than to the mechanical injury caused by the girdling of the inner bark by the insects. Considerable work on ecological factors laid the basis for proper practical handling of stands to minimize damage as, for example, in showing that pine could usually be cut during the summer period without causing bark beetle outbreaks, provided there is a continuous supply of fresh slash, kept away from living trees. Among other notable achievements in this field were the sap stream methods of controlling beetle attacks and of preserving standing and freshly cut trees from insects and decay, developed at the Appalachian Station; early work on the testing of chemical sprays in the control of bark beetles and wood borers; and methods for controlling white grubs in pine nurseries, a bad nursery pest in the widespread planting activities of the 30's.

During the same period some preliminary work was done in cooperation with the Fish and Wildlife Service (then Biological Survey) on distribution and life history of birds and mammals of this region, with special reference to the role of rodents in forest regeneration after timber cutting. The Station also carried on independently work on the microfauna of forest soil and litter and their role in litter reduction and soil improvement. Unfortunately, this work could be financed on an emergency basis only and was soon dropped.

In the field of fire the work already cited on the dominant role played by fire in the introduction of heart rots in hardwoods led to a method of predicting volume loss at future dates from width of wound (Hepting: Jour. Agr. Research 62). This in turn led to an improved method of appraising timber damage (Jemison: Fire Control Notes, 1941) now adopted by all of the southern states.

The greatest step ahead in forest protection, however, was probably in the field of fire control. As noted, McCarthy's early interest in the relationship between fire and weather led to the establishment of a fire weather forecasting service in the Appalachian region. As a necessary accompaniment to this the Station undertook, in cooperation with administrative forest officers, a comprehensive study of various aspects of fire control, such as the detection of fires; the weather and fuel factors (rain, wind, humidity, moisture content of litter) influencing the occurrence of fires and the rapidity with which they would spread; the relative difficulty of control in various kinds of fuel, as grass or hardwood leaf litter. The work had a number of practical applications. Improved knowledge of the visibility of small objects, such as smoke columns in a natural landscape (Byram: Jour. of Optical Society 34), led to eye tests for selecting better observers and to haze meters for measuring the distances to which lookouts could detect smoke under varying atmospheric conditions. The discovery of the polarity of industrial smoke and haze led to the invention of a haze filter which permits the lookout to see fresh smoke further through such haze and may increase his visual range by 25 percent on average hazy days. Better placement of lookout towers, reduction in the cost of lookout services (in one case these were halved), and improved detection services resulted. A system was developed of evaluating various types of fuel from the standpoint of how fast fires would spread in them, and how difficult such fires would be to control. This knowledge plus widespread mapping of the fuel types helped in the effective location of roads, trails, telephone lines, and standby crews so as to make possible the cheapest and most efficient protection. Some preliminary research was made in the field of fire weather (Pierce: Monthly Weather Review 62). Information on the relative danger of fire occurrence and spread under different conditions of wind, wetness of the fuels, the greenness of vegetation, and so on, were summed up in a fire danger rating system (Jemison: Station Tech. Note No. 36). This supplemented unsupported judgment with scientific measurement and eliminated guesswork in the day-by-day planning of the fire control organization needed to meet existing danger. It effected savings by making fire men available for non-fire work when fuel and weather conditions permitted. In order to get a practical and inexpensive system, special instruments had to be invented. One of these, the Appalachian Fuel Moisture Scale, is now widely used throughout the United States and in several foreign countries.

Seeding and Planting

The difficulty of establishing suitable trees on the abandoned and commonly eroded fields of the Appalachian Valley and in former spruce-fir areas on the upper slopes and ridges has already been mentioned. Early work in both types had indicated some of the appropriate species to use, but the actual selection of the right tree for the right place, as well as the development of associated planting techniques and cultural methods, presented unusual difficulties because of the drastic environmental changes brought about by clearing, fire, cultivation, and accompanying top soil losses. Experiments during the middle years gave satisfactory and fairly categorical answers to the questions of how, where, and what to plant, and what cultural treatments are necessary to secure satisfactory survival and early growth (Minckler: Ecological Monographs 16; Jour. Forestry 43). One interesting feature in this work was the advent of a new cooperator, the Tennessee Valley Authority.

A minor though tough management problem tackled in this period was the planting of so-called laurel "slicks." These are extensive areas in the mountain region, almost treeless, where dense laurel and rhododendron thickets are occupying productive land and effectively preventing or retarding tree regeneration. The Station now has experiments in the pilot plant stage indicating that white pine seedlings, planted in cleared lanes (three-fourths as wide as the laurel is high) will overtop the laurel before the lane closes, and will thus reforest the land. Potential returns from the pine should more than pay the costs.

Other Work

The first substantial increase granted the Appalachian Station ($18,000 in 1927) permitted it to broaden its program into three additional major fields. Two were functional: forest influences (watershed management) and forest economics (the forest survey). One was geographic: the extension of work in mensuration and silviculture to the pine types of the piedmont and coastal plain.

Watershed Management

Watershed protection was one of the prominent motives back of the enactment of the Weeks Law, under which the national forests in the southern Appalachian region had been established. The initial report of the Appalachian Station recognized the need for "studies of forest cover in relation to stream flow and erosion," and this need had been given fresh emphasis at the Southern Waterpower Congress at Asheville in June 1922. Nevertheless, it was ten years (1931) after the establishment of the Station before a small appropriation of $6,000 was made available for the formal study of such problems.

The development of the Coweeta Hydrologic Laboratory with emergency relief labor, about 1934-35, furnished the physical facilities for a substantial program. The Coweeta area, an outdoor laboratory of approximately 4,600 acres, with some 40 independent well-defined drainages and with a high annual rainfall well distributed throughout the year, furnished ideal conditions under which to study forest-stream flow relationships. By 1935, 26 controls were in operation to record stream flow on small drainages. A complete series of meteorological stations was installed, and 16 ground wells were established for the observation of water-table fluctuations.

The first work confirmed observations elsewhere as to the effect of forests in the reduction of peak flows. Continued studies emphasized the complexity of the problem and resulted in fundamental contributions to the science of forest hydrology, early appreciated by top engineers but not yet widely known to foresters. For example, the general shape of storm hydrographs during short intense storms resembles the shape of hydrographs produced by surface or overland storm runoff from relatively impervious land surfaces. Hydrologists had interpreted this as meaning inadequate infiltration of rainfall into forest soil, a point immediately contested by foresters. The Station's studies showed that these rapid rises in streams from forested areas are due almost entirely to flow from rain falling directly in the stream channel and not due to lack of infiltration into the forest soil. By establishing the exact contributions of channel precipitation to runoff on a watershed basis (Hursh and Brater: Trans. Amer. Geophys. Union, 1940) it was possible to clarify the situation and eliminate one of the obstacles to a better understanding of forest-stream flow relationships.

It was demonstrated also that during periods of heavy protracted rainfall some of the rain that enters the soil reaches the stream as subsurface storm flow in time to contribute to the storm hydrograph. The nature and extent of this process, never before clearly shown, was explained by movements of the water table as recorded in observation wells. These studies proved the existence of a relatively rapid lateral movement of water through the porous forest soil and demonstrated the inapplicability of transmission formulae heretofore applied.

Of special significance from the standpoint of fundamental hydrology and in flood control was the elaboration of the water balance concept (Hursh, Hoover, and Fletcher: Trans. Amer. Geophys. Union, 1941). It was clear from Coweeta records that the effect of vegetation on stream flow at any given time on a given watershed could only be understood by an adequate knowledge of the entire water economy of the area. For example, in comparing the stream flow from a clear cut watershed with that from a forested watershed, an increase in runoff of 65 percent was recorded for the cutover area for the first year, with smaller but material increases in successive years. The 65 percent increase is attributed to the water that would normally have been transpired by the trees. The marked increase in water yield following vegetation removal (but without soil disturbance) is regarded as highly favorable and indicates the feasibility of integrating water and timber management. A feature of the increased water yield is that it comes in the late summer and fall months when stream flow in the Southern Appalachians is ordinarily lowest, and industrial and domestic water is at a premium. Under other circumstances or in other places conditions and effects might be radically different, illustrating how important it is to have an adequate knowledge of the water balance of a given area, the true water economy, for the proper interpretation of stream behavior and comparison of watershed treatments.

Continued experimentation is leading to a much better understanding of the effects of various common types of land use, agriculture, grazing, fire and timber harvesting, on stream flow. These results should find ready application in the practical management of the water resources of all forest land.

Forest Economics

Prior to the late 1930's no adequate data were available on forest acreage, timber and cordwood volumes, current timber growth and similar basic statistics for the Appalachian region. A national forest survey to provide such facts had been provided for in the McSweeny-McNary Act of 1928, and in 1936 work began at the Appalachian Station. A start had already been made under the direction of the Southern Station in the field inventory of South Carolina. By 1940, essential field work had been completed for the Carolinas and Virginia.

Even before the State findings could be summarized, requests for survey information were received from foresters, land-use planners, and the wood-using industries. The burden of requests soon became so heavy as to constitute an important part of the work of the Survey staff. Numerous federal and state agencies (such as the Bureau of Agricultural Economics, the Soil Conservation Service, the Tennessee Valley Authority, State Planning Boards, and the State Forest Services and Extension Services) requested special tabulations in analyzing local land-use problems and in developing programs. The Forest Service has used such data locally and nationally, as in presenting material to the Joint Congressional Committee on Forestry, to the Natural Resources Committee, and to the public (USDA Misc. Pub. Nos. 533 and 552). In addition, pulp and paper companies and wood-using concerns of all kinds have drawn upon the survey for data and services in planning the location of plants, the procurement of raw materials, and so on.

Indeed, the uses for forest survey data seem endless. The need for them is sharply illustrated by the inadequacy of previous estimates. In North Carolina, for example, it was found that although the acreage of forest land was slightly less than in previous estimates, the volume of saw timber was over twice as great as estimated, i.e., 44 billion as against 19 billion board feet, while the number of operating mills was found to be over three times the number previously reported. Errors of this magnitude are incompatible with sound industrial planning and policy formulation on either an industrial, state, or national level.

Coastal Plain and Piedmont Research

The middle years also saw substantial expansion of the Station's program into the important piedmont and coastal plain types. This work remained a relatively minor part of the Station's total program. But a mill scale study (Korstian, Garver, Cuno, and MacKinney: Virginia Forest Service Pub. No. 43) showed the wastefulness of cutting small trees and led to the recommendation of selective (partial) cutting for the coastal plain types. Later work added to available knowledge on seed production and seeding habits, the growth rate and mortality in residual trees, and the causes and extent to which low value hardwoods were invading recent pine sites. All of this aided in prescribing sounder cutting practices. The productivity of the loblolly forest was also studied and yield tables constructed for estimating the forest products that could be grown. One of the most important contributions was a method of constructing yield tables from mechanically selected field plots (MacKinney, Schumacher, and Chaiken: Jour. Agr. Res. 54). This development in technique partially replaced the old "normal" plot method and resulted in improved yield table construction.

McQuilken, experimenting with artificial regeneration of abandoned fields in the piedmont, described the conditions under which planting or seeding was needed and feasible. Later work by Minckler (now in the pilot plant stage) gives promise of developing a method of direct seeding which will furnish practitioners a satisfactory supplement to normal planting practice.

During the middle period the Station profited from the advice and guidance of a 21-man Advisory Council of leading foresters, educators, and forest industrialists, which met periodically to review Station progress and program.

THE WAR AND POST-WAR YEARS 1942-1946

Within a week after the declaration of war the Station began to convert from a strictly research to a war service agency. Such a move had long been foreshadowed by world events, and the Station's plans were well formulated when the actual outbreak occurred. A trained staff was placed on War Production Board surveys to determine the quantity and availability of various war materials such as chestnut extract wood for tanning, oak ship timbers, pulpwood, yellow-poplar for aircraft, and so on. A continuous inventory was started of monthly lumber stocks and monthly lumber production as a basis for allocation of steadily scarcer raw materials. A periodic examination and report on factors affecting production was undertaken as a means of speeding up output. To these surveys the Station at times devoted all available technical manpower, aided by the effective assistance of the Regional Office at Atlanta and the Forestry Relations Division of the Tennessee Valley Authority. In addition to recurring monthly and quarterly reports, the Station made over 30 special surveys, some of considerable magnitude. A successful effort was made to keep the forest survey data up-to-date in the Carolinas and Virginia by current estimates of growth, mortality, and drain.

Numerous other jobs fell in the war category. At the request of the Eastern Defense Command, U. S. Army, a network of some 140 fire danger stations in 14 northeastern states was organized and knit into one unit in a general move to improve fire control around critical war industry areas and coastal regions. The main responsibility for the operation of this highly centralized unit fell upon the Regional Forester at Philadelphia, but the Station's know-how in fire danger measurement was essential in locating and operating the fire danger stations involved. Under war stimulation the Station's system of measuring fire danger was adopted as a permanent basis for fire control planning by 22 States and some 30 other fire control agencies. By 1946 some 439 fire danger stations were in operation.

The Station also prepared, in cooperation with Region 7, an intensive plan concerning the possible use of fire as an offensive-defensive weapon along the eastern seaboard from Maine to Virginia. This was a big job, including the construction of detailed fuel-type maps for a 15-mile coastal-wide strip, the compilation of fire behavior data, and description of techniques of using fire.

Information from fire studies was also used to help the war effort in other ways. An incendiary raid meter was developed to rate the conditions most suitable for fire raids on enemy countries. Basic information bearing on the visibility of small objects served as an aid in camouflage, artillery ranging, and other military problems.

The Station also pressed vigorously its new work on forest grazing in the eastern coastal plain pineries, as a less direct but important war aid through the production of maximum amounts of beef and hides. These forest grazing studies, conducted cooperatively with the Bureaus of Animal and Plant Industry and the North Carolina and Georgia State agencies, had been started in 1940 as a result of growing interest in the improvement of cattle production in the pine forests of the coastal plain. Although the pineries had served as range for cattle since the days of the Spaniards, production had never been great and war demands for beef and hides emphasized the desirability of increasing it if at all feasible. The early grazing experiments indicated the possibilities of increased production. Even where forest areas are managed primarily for timber, grazing provides supplemental income and other benefits such as reduced fire hazard and better early growth. Under favorable circumstances, as in good reed beds, production might be substantial. Even in the less productive wire grass type, supplemental net returns of fifty to seventy-five cents per acre per year seem feasible. Better returns should be possible if research shows how to increase the calf crop, as now seems probable.

Work to date has outlined the importance and extent of the grazing industry and its major problems (Biswell, et al.: N. C. Agr. Exp. Sta. Bul. No. 334; Ga. Coastal Plain Exp. Sta. Cir. No. 8); described the native forage including poisonous plants and how to minimize stock damage (Ga. Coastal Plain Exp. Sta. Bul. No. 37; N. C. Agr. Exp. Sta. Bul. Nos. 342 and 353); confirmed the value of prescribed winter fires in the wire grass type in increasing forage values and cattle gains. Increased gains averaging 44 pounds per head were recorded on prescribed burned as against unburned range. Two satisfactory systems of cattle management have been developed, both requiring supplemental feeds (cottonseed meal, sugar cane, ensilage, hay, etc.) during the fall and winter months.

Various activities of the cooperating Division of Forest Pathology also fell in the war category. Studies of discolorations in yellow-poplar veneers and lumber showed most of the discolored wood sound and of normal strength. This raised the production of acceptable material of this critical item an estimated 25 percent during an emergency period. Practical measures were formulated to avoid decay in wood aircraft and these were adopted by the Air Service Command and the aircraft industry to make wood airplanes safer.

In addition, time was found to keep minimum records on long-time Station experiments where complete cessation of work would cause unjustifiable loss of past effort. Most of the time-consuming projects in timber-growing and watershed management fell in this class. For example, if the value of eight years of work at the Coweeta Experimental Forest was not to be almost completely lost and incalculable damage done to the continuity of stream flow records, it was necessary to keep the half-million dollar plant of weirs and other water-measuring equipment on a minimum operating basis. Long-time experiments in forest management were also put on a purely maintenance basis.

In addition, the Station carried forward a few active essential projects. Work continued on "littleleaf," a disease killing maturing shortleaf pine over hundreds of thousands of acres throughout the piedmont and upper coastal plain of the South (Hepting et al.: USDA Cir. No. 716). The cause of this disease is not yet known but the work to date strongly indicates nutritional difficulties. Application of nitrogen tends to prevent littleleaf among healthy trees and induce recovery in diseased trees.

In forest management a new and relatively simple method of predicting growth in uneven-aged hardwood stands was developed (Buell: Duke School of Forestry Bul. No. 10). If the method can be broadened for general application, it marks one of the most important contributions in forest mensuration to date.

Some time was spent, especially toward the close of the war, in post-war planning and forest economics. The Station aided in the national reappraisal of the timber situation now being reported in a series of Forest Service releases. A post-war forest program was prepared for the Appalachian region. The role of farm and forest resources in the eastern Kentucky Highlands was analyzed (the work of the University of Kentucky and the Kentucky Agricultural Experiment Station with Appalachian Station cooperation) and a forest rehabilitation program outlined. The first of five publications reporting these studies has now been printed (Duerr: Kentucky Agr. Exp. Sta. Bul. No. 488). Another investigation in forest economics resulted in improved techniques of determining the most profitable fire control expenditures, clarified the type of basic data needed, and indicated the probable size of justifiable expenditures for several study areas. Much past work was summed up for publication, Station releases totaling 31, 25, 63, and 29 in the years 1942 to 1945, respectively, including 3 to 5 printed reports each year (bulletins, circulars, or longer articles) embodying major contributions to forest science.

Conversion to a peacetime basis took place in part even before the end of hostilities. Increased allotments in both 1945 and 1946 provided for a greatly enlarged experimental forest, range, and watershed program at a series of decentralized work centers representative of the major forest and physiographic types. A reorganization of the eastern stations' boundaries in 1946 gave the new Southeastern Station responsibility for naval stores research in addition to other work in Georgia, Florida, the Carolinas, and Virginia. Work continued on naval stores production problems, especially on the technique of bark chipping with acid stimulation, which promises average net profits at current prices of over $1,000 more per crop of 10,000 trees. Successful rooting of cuttings from merchantable-sized longleaf pines was done for the first time. Rooted cuttings and hybrid seedlings from high-yielding trees, promising to yield twice as much gum or more per tree as at present, were outplanted for field trial. The naval stores program was enlarged to include work on the mechanization of naval stores operations as a measure to reduce production costs.

The establishment of a Forest Utilization Service, in late 1945, rounded out the Station's organization. This unit provided a technical liaison between the Forest Products Laboratory at Madison, Wisconsin, (where federal utilization research is concentrated), and the Station and wood-users. Its objective is to better forest utilization in the broadest sense. It has already helped the wood-using industries improve lumber-drying practices and reduce waste by promoting a series of courses in better drying practices in cooperation with such organizations as the Southern Furniture Manufacturers' Association. Several surveys of wood-using industries were made to determine current practices, such as glues and gluing and sawmilling, as an indication of needed improvements. Cooperative work was started with the North Carolina Agricultural

Experiment Station and the Tobacco Experiment Station of the Bureau of Plant Industry, Soils, and Agricultural Engineering to develop a new type of wood-burning tobacco barn furnace. The work was begun because the continued use of wood as fuel for tobacco drying offers a splendid opportunity to improve farm wood lots; to maintain this large outlet for thinnings and low-grade wood, the farmer must have a convenient and efficient wood burner.

A bulletin, "The Preservative Treatment of Fence Posts," was prepared at the Station and published by the North Carolina State Department of Conservation and Development. As a result of this work, some eight plants are now in operation or under construction in North Carolina, and additional plants are planned. This bulletin is to be a part of a series on wood-using industries suitable to North Carolina. A general bulletin, describing the forest situation in North Carolina and the sound forest industry developments that can be based upon it, was also prepared and is in the hands of the printer.

A LOOK AHEAD

It is clear that we now know a great deal more than in 1921 about the proper management of forest lands in the Appalachian region. Tangible evidence is some 500 releases and publications issued since 1921 by the Appalachian Station and its cooperators. Meshed with this is knowledge gained by other research agencies, by informal observation, by commonsense deduction, and by practice and experience. Substantial progress is evidenced by more effective protection, a better understanding of forests and stream flow, increased growth of beef as a supplemental forest crop, the general better utilization of other forest crops. Methods of seeding and planting are much improved. It is feasible to describe forest improvement and desirable harvesting practices in specific terms. We have a more reliable forest inventory on which to base national, state, and industrial planning. Even the war years were productive of new knowledge in forest economics, forest grazing, fire protection (both fire and diseases), forest planting, and better forest utilization.

Nevertheless, each successive reappraisal has shown a steady deterioration of the national and regional forest situation. The basic cause is that timber in the past has rarely been considered or grown as a crop on private land. A recent reorganization of eastern stations has given the new Southeastern Station responsibility for forest research in five States, Virginia, the Carolinas, Georgia, and Florida. These States must product about one-fourth of the wood products and almost all of the gum naval stores needed to meet national requirements. Under the circumstances, what role can this Station best play in the southeastern picture? In what fields and by what types of studies can it advance forest science and hence forest practice in the most effective way?

It would seem that the main job for research is to furnish the information needed to grow timber as a crop for private profit on privately owned lands. In the Southeast about 90 percent of our forests are so owned. Any knowledge that can help toward this end, by reducing production costs or increasing the quantity, quality, or utility, and hence the profitability of the crop, will be directly helpful. It is true that a public research agency such as the Southeastern Station has other obligations, as in determining the relationship between forests and water so that watershed lands can be managed in the best public interest. But in the main, the formulation of methods for growing timber as a crop at the lowest cost and highest profit would seem the most important single job ahead if the present discouraging forest situation is to be remedied.

Although much past work is applicable to private land problems, a further shift of research emphasis in this direction would seem timely and desirable for other reasons. Heretofore, the lumber industry, the main harvester of timber crops, has been a migratory one. But over the last decade or two a considerable number of far-sighted substantial forest owners and operators have begun to see, particularly under more favorable conditions such as exist in the South, an opportunity for private profit in timber growing. This trend should furnish customers for research results who were often lacking heretofore. The acquisition of large forest land holdings by the pulp companies, widespread interest by many landowners and forest industrialists, and industry's employment of technical foresters by hundreds rather than by two's or ten's, are all substantial indications of present trends.

Accordingly, in late years and especially since 1945, the Station's program has been reoriented to lay special emphasis upon discovering and organizing the knowledge that is essential to private landowners growing timber for profit. On reasonably good sites, the timber owner can increase his profits by practicing forestry more intensively than he has in the past. This has certainly been the trend upon a number of private forest properties put under management in the last several years, as well as on existing older public properties. Although a program of work must be continued to fill gaps in our present knowledge of silvics and silviculture, major emphasis in current programs is being laid on commercial tests of what we know - that is, tests on a pilot plant or commercial compartment basis rather than on a small plot basis as in the past. Also, emphasis on production costs and profit returns is needed as well as on silvicultural results. It is hoped that this work will fill the gap between what we now know and what the forest practitioner must know if we are to understand the possible returns from timber growing and the procedures necessary to produce timber and other forest crops profitably on substantial areas throughout the southeastern states. Activities along this line and in related forest research fields will comprise future annual reports of the Southeastern Forest Experiment Station.

THE FOLLOWING PAGES CONTAIN DETAILED REPORTS OF THE SEPARATE FIELDS OF WORK, WRITTEN BY THE DIVISION LEADERS.

FOREST MANAGEMENT, 1921-1946[1]

How to grow the most wood products of desirable quality at the lowest cost--that has been the goal of the Forest Management Research workers at the Appalachian Station for the past twenty-five years. From the very beginning of formal research in 1921, problems in how to produce more and better timber loomed large in the Station program. Even though much of the early work involved gathering general information from observational-type studies on the major forest production problems, fundamental studies also had their place.

The Station was originally charged with responsibility for work in the mountains, and so early effort was logically confined to Appalachian hardwood problems. Later, the scope of investigations was broadened to include some study in the piedmont and coastal plain pine and pine-hardwood types. Recently, a major expansion of Forest Management work has broadened the program both geographically and functionally. This historical development will be brought out in the following description of accomplishments in the Forest Management field.

Silviculture of Appalachian Hardwoods

Throughout the 19th century, beginning with the influx of settlers soon after 1800, the forests of the Southern Appalachians were converted from the virgin stands of prime oaks, yellow-poplars, and maples to the severely deteriorated and run-down condition found today. Land clearing and abandonment, unrestricted fire and grazing, cutting of the best trees, and finally the inroads of chestnut blight all contributed in a major way to the rehabilitation problem of poorly stocked, low quality stands confronting the landowner today.

Stand Improvement

It was natural that from the beginning the Station's program included studies of how to rebuild the once-valuable hardwood forests. Reconnaissance of the cutover and burned forests led to the establishment of the first stand improvement studies in 1924. Technical answers to the many problems of stand improvement, such as cull disposal by felling, girdling, and poisoning; when and how to weed young stands to improve composition, tree form, and thriftiness; how to thin yellow-poplar stands properly; and how to bring about general rehabilitation of run-down stands were becoming available by the late 1920's and early 1930's.

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[1] Prepared by George M. Jemison; in charge, Forest Management Research, Southeastern Forest Experiment Station.

With the advent of the Civilian Conservation Corps program in 1932, there developed an urgent need for information to guide broad scale timber stand improvement programs. Bulletins and handbooks were made available to guide the extensive stand improvement work done by the CCC. Later studies of the benefits of some phases of this improvement work have verified the soundness of its technical basis.

But there were many unanswerable questions brought up by the CCC timber stand improvement program and many mistakes were made. The Station set about investigating these problems and in the past ten years has contributed in a major way to the further understanding of stand improvement. Final results have been compiled from experiments in weeding young hardwood stands to improve the species composition, in liberation of white pine (a species of increasing importance) from decadent hardwood overstories, release of individual trees from overhead and side competition to maintain or increase their growth rate, thinning of even-aged stands, and live pruning of white pine. The cooperating Bureau of Plant Industry, Soils, and Agricultural Engineering has contributed extensively to the knowledge of handling sprout hardwoods to maintain high quality and vigor, and of pruning hardwoods without danger of serious decay.

At the present time, all available information on timber stand improvement is being summarized in handbook form, and the laboratory phase of the project can be considered near completion.

Harvest Cutting

The silvicultural aspects of harvesting mature hardwood timber have posed many varied and complex questions. Early observations indicated that the mixed hardwood forest of the Southern Appalachians, containing 45 or more commercial species, could be handled by the selection system which called for partial cutting in the uneven-aged stands. A bulletin on timber growing and logging practice in 1931 set forth both minimum practices and those recommended for full production of forest products.

Major management bulletins or reports on Atlantic white-cedar (1931), yellow-poplar (1933), and red spruce (1937) were monographs that actually went beyond harvest cutting problems. They served as summaries of all known cultural and silvical information on the species. The knowledge set forth in bulletins of this type was supplemented in the 1930's by study of the condition of cutover areas in the Appalachians and definition of their needs. Basic information on natural reseeding and growth of residual stands collected during the 1930's has made possible an improvement of the definition of minimum cutting practices as part of the Forest Service program in 1946. The same information has shed light on the best methods of applying the system of partial cutting.

Silvics

Progress in general management practices has depended heavily on basic silvical and ecological information. When the chestnut blight removed one-third of the timber volume of the Appalachians, it was felt that the forests might have to be replanted if they ever amounted to anything. A careful study of areas suffering from the blight showed definitely (1926) that young trees of desirable species and form quickly took over the position of chestnut in the stand. Study of seed production characteristics of five important oak species (1944) and the factors controlling germination of acorns and early survival (1927) of seedlings showed what requirements must be met in partial cutting to insure adequate seedling reproduction.

Silviculture in the Pine Region

The original piedmont forests were almost entirely hardwood, but the clearing, cultivating, and abandoning cycle of the 1700's and 1800's resulted in widespread occurrence of pure old field pine stands. More than half of the forested area of the piedmont is still in pine. Although many of the coastal plain pine forests originated on abandoned farm lands, extensive natural pine forests existed and were perpetuated by fires that checked the natural succession to hardwood species. Pine forests in both regions offer fewer complex problems than the Appalachian hardwoods, but still the best methods of managing them are not fully known.

Silvicultural studies in the pine regions of the piedmont and coastal plain have been more limited than those for mountain hardwoods, but some notable contributions have been made. Considerable information has been obtained on the still-controversial hardwood encroachment problem in pine areas. A detailed study (1943) has shown how serious the problem actually is, and other work has pointed to means of overcoming the undesirable trend toward hardwoods. Methods of poisoning large cull hardwoods have been worked out.

The increased demand for pine pulpwood of the last decade has made early commercial thinnings in young pine stands profitable. Results of thinning in various intensities have been studied for loblolly and longleaf pine.

Requirements for seeding in cutover loblolly pine areas have been determined. Studies of seed production and seed distribution of loblolly pine have led to definitions of restrictions that should be imposed on clear-cutting and the specifications for seed trees (1944). The establishment of pine in abandoned fields of the piedmont depends on nearness to good seed sources. Characteristics of such seed sources have been determined (1940).

In parts of the piedmont, ice storms are extremely damaging in pine forests, especially those recently thinned. Rules for minimizing glaze damage (1943) have been developed to assist the land manager in overcoming this hazard. In 1946 measurements on more than 250 plots were used to strengthen the knowledge of glaze damage as related to stand conditions and methods of cutting.

At the year's end (1946), a comprehensive study of the behavior and control of hardwoods in the South Carolina coastal plain loblolly pine region has been started. The study is divided into three phases: (1) basic investigation of hardwood growth rates under overstories and after release, growth of sprouts, growth following defoliation by silvicides such as 2,4-Dichlorophenoacetic acid (2,4-D), and relation of hardwood vigor to site, (2) the control of understory hardwoods in immature pine stands so that they will offer no serious competition to pine seedlings at the time of the reproduction cut, and (3) the control of understory hardwoods at the time of the harvest cut. Numerous treatments involving various combinations of prescribed burning and silvicide treatment are included in the studies. The hardwood encroachment problem is being analyzed more thoroughly in the piedmont following a 1946 reconnaissance of stand conditions.

Because of the interest in growing pine pulpwood as a final crop, an experiment has been started to determine if pre-cutting release of selected seed trees will stimulate the early production of adequate seed, so that hazards of making a successful reproduction cut in young pine can be eliminated.

Plantation Management

Worthy of special note is the work completed on plantation management. Early in the Station's program an exhaustive analysis (1930) capitalized on the experience of Dr. Schenck on the Biltmore Estate. This made evident the fact that hardwood plantations would not succeed on badly eroded, abandoned farm land. But more important, the presence of a large area of old plantations enabled an early study of thinning. Beginning in 1916, even before the Station was established, some of the plantations have been repeatedly thinned to provide excellent information on plantation management.

Artificial Regeneration

In the Great Appalachian Valley and adjacent highlands there are about three million acres of unproductive land capable of producing forests. Some of this land has been cultivated, impoverished, and abandoned. Other denuded and burned forest lands are incapable of natural recovery by desirable tree growth. Beginning in 1937, following preliminary exploratory studies dating back to 1922, a major investigation of methods of reforesting such areas was started.

Species Adaptation

How to insure planting the right tree in the right place has been one of the outstanding contributions of the Station's planting studies. Based on the survival and growth data from more than 700 experimental plantings, the results show the importance of soil, topography, and vegetative cover to successful planting for important hardwood and coniferous species. The studies have resulted in the compilation and wide distribution of planting charts and guides which indicate what trees to plant for each combination of soil, site, and cover condition. The adaptation of species to site has proved its importance and value in a successful large-scale pilot plant test begun in 1940, in which the planting guides were used.

In addition to insuring the planting of the right tree in the right place, the studies have contributed significantly to a better understanding of the fundamental relations of soil type and condition, climatic factors, and competition to plantation success.

Spruce Regeneration

Unfortunately, the cutover and burned spruce lands in the Appalachians had resisted early efforts to convert them to revenue-producing areas. In 1924 studies were begun by testing the adaptability of twelve coniferous tree species to the high elevations of the spruce type. In 1940 studies were intensified to find out how to bring back forests on these denuded lands. A program that involves planting combined with release or the use of super-stock has been developed. Direct seeding methods for reforesting severe rocky sites have been perfected. Recommendations which vary with vegetative cover and site are being used in practical reforestation programs.

Laurel Replacement

Increasing the productivity of worthless laurel and rhododendron brush fields has long been a problem in the Southern Appalachians. Research at the Station begun in 1931 has determined how this can be accomplished through planting white pine. Special techniques of site preparation, derived from studies of many possible methods, are required to insure success of the plantations. While calculations indicate conversion to white pine will be financially profitable, large-scale pilot plant tests are under way.

Direct Seeding

Direct seeding as a substitute for or supplement to planting has intrigued foresters who envisioned that seeding might reduce reforestation costs and produce better stands of trees. Complete studies, begun in 1939 and now in the pilot plant stage, have shown the requirements for successful direct seeding of pine in the piedmont region and have emphasized its limitations. Direct seeding can be considered a useful and economic supplement to the planting method. Machine techniques for direct seeding have been developed to reduce its cost to half those of ordinary planting. Rigid but highly practical methods must govern the direct seeding work. Early studies of direct seeding of high-value yellow-poplar showed planting of seedlings to be far more practical.

Seed Studies

Numerous studies of seed germination, storage, and treatment have contributed to efficient nursery practice. In 1928 a study of the germination of pitch pine seed was completed. Requirements for storage of acorns and guides for planting in nurseries were completed (1930). Treatment of loblolly pine seed to maintain viability in storage and obtain high germination in nurseries contributed to the success of artificial regeneration of this important species.

Mensuration

Mensurational studies began somewhat incidental to associated work in Forest Management and silviculture, and did not gain full impetus until the mid-thirties, when an intensive, Station-coordinated project was initiated in loblolly pine. There followed a period of notable progress in both methodology and usable results, which continued up to the war years and the interim abandonment of a mensuration program per se. Perhaps the most important development of the period was a method of constructing yield estimates which for the first time provided for the use of mechanically selected field plots instead of the classic ocularly chosen "normal" plots. This procedure plus ingenious use of the logistic curve and a contribution to normality adjustment refined the technique of yield table construction.

This same period showed marked improvement in the development of volume tables and techniques for their formulation. Prior to 1938, volume table construction was more or less a regional problem with little emphasis on the needs of the small holding and the farm owner. With the developing economic importance of the woodlot and the numerous small non-farm wooded areas, the demand for volume tables for local application fostered a slow but determined shift in emphasis to methods which permitted reliable estimates for relatively small volumes. The older methods by diameter and height were supplemented by the so-called "form-class" table, requiring an additional measurement in the ratio of o.b. diameter at the top of the first log to the o.b. diameter at breast height. Tables are now available for the commercial mountain hardwoods and most of the native softwood species, including loblolly and Virginia pines.

A demand for converting factors has existed over the years, and these needs have been currently met in the mensuration field. For example, factors for converting round and split oak topwood to stacked volume were developed in 1941. Conversions of stocked volume to solid volume have been made available.

In many-aged mountain hardwoods, reliable methods for predicting periodic growth have been known and in use for some time. However, their acceptance and application have been limited by their complexity and high cost. Early efforts to simplify the problem by generalizing case histories or increment core analyses proved unsound or impracticable. Therefore, in 1934, three thousand permanent sample plots were established in seven locations in the Carolinas, Georgia, and Tennessee for the primary purpose of developing an accurate, simple, reasonably cheap predicting mechanism. A six-year record of these plots formed the basis for a published method which permits an estimate when only the diameter distribution of the stand is known, and in addition provides a separation of growth into the components, mortality, and recruitment.

Characteristic of research programs, not every study is marked for positive success. As a correlary to growth in uneven-aged hardwoods, repeated attempts have been made to correlate diameter growth of individual trees with easily recognizable external tree characteristics other than d.b.h. Of the great number of variables treated for white oak and shortleaf pine, none have been outstandingly successful; a few are still retained for future work. Similar studies to anticipate and provide prediction equations for mortality have also been only partially successful.

Financial Aspects of Forest Management

In spite of valuable early contributions, there has been an outstanding lack of adequate information on the costs of and returns from management. Probably the earliest specific attempt to show the costs and values associated with logging and lumbering was made in 1929. A cooperative study by the Forest Products Laboratory, the Region, and the Station showed how costs per thousand board feet decreased and how lumber values increased as mountain hardwood tree and log size increased. This study pointed out the importance of the small sawmill and its place in the economy of managing Southern Appalachian stands. A major study was made in 1930 to show the financial aspects of "selective" logging in the loblolly pine type of the coastal plain. In addition to finding the comparative costs and returns of cutting various sizes of pines and hardwoods, the economic feasibility of relatively light selective cuttings was demonstrated. This was probably the first demonstration in the southeast of the then highly contentious theory that selective cutting was feasible.

In both of these early studies and others made later, the comparative basis for production costs was the dollar (per M bd. ft.) rather than a unit of time such as man or crew hours. Comparisons of costs of management or of one method over a long period of time were not only difficult but risky. As a result of these difficulties and the desire to obtain grade yields by log grades, an intensive logging and milling study was made in 1945 at the Bent Creek Experimental Forest. This study determined detailed production costs in terms of both time and dollars per M bd. ft.

At the year's end (1946), this study has been expanded to include a wider variety of conditions.

A study completed in 1939 analyzed the factors affecting cost of producing oak cordwood. It showed time and cost data for bucking, peeling, splitting, and skidding wood. The effects on costs and profits of changes in wage rates, margins for profit, and cuts per acre were determined. Other studies on production costs have been made for various types of pulpwood cutting in loblolly and Virginia pine, including relation of costs to silvicultural method, intensity of thinning, and type of equipment used (1946).

Determination of the general costs of and returns from management have been approached through numerous studies in the past. Analytical reports summarizing the status of knowledge have been included in the timber growing and logging practice bulletins, in studies of white-cedar management, and in the selective logging studies mentioned above for pine and hardwoods.

Instruments and Equipment

Like all research workers, those engaged in studies at the Appalachian Station have been constantly forced to develop tools with which to work when standard equipment was not available. The invention of equipment or devices used for the forestry profession constitutes a worthwhile contribution. Many such devices have been developed in the past 25 years, including circular slide rules, height-measuring apparatus, diameter tapes, tree crown profile projector, sag-measuring instrument, tree form class device, tree poisoning tool, and many others.

Experimental Forest Management

Throughout the years of observation and fundamental study, there has accumulated a tremendous volume of basic information on forest management. Adequate information on the costs and returns of good practice--something needed if the private landowner is to be interested in improving his methods--has been woefully weak, however.

In 1945 an expansion of the forest management program enabled a shift in emphasis to be made toward testing major management systems on a cost and return as well as a silvicultural basis. The accumulated information in silviculture, mensuration, and regeneration has enabled a sound and realistic plan of experimental forest management to be developed.

Within homogeneous sub-regions or "work centers," groups of foresters are now working on the major management problems by operating one or more experimental forests. As actual land managers these workers are testing, on a commercial scale, various methods of handling timber lands.

Financial aspects loom large in the program of studies. Special investigations of problems growing out of the land management work are also being carried on.

Adoption of the "work center" approach is a logical step in the determination of the best forest management practices. Just as in industry where the findings in the laboratory are put through a pilot plant stage before large scale production starts, so forest management methods must be tried extensively but with adequate controls to insure the soundness of the test.

Farm woodland management is being tested on a practical scale, with sustained yield programs being carried out as any well-informed farmer might do. Sets of books reflect the profit or loss aspect of the operations.

The progress at 8 of these field centers was significant in 1946. At the Olustee and Hitchiti Experimental Forests, established for several years, the program of cutting on a pilot plant scale was completed through the first cycle. At newer areas plans for establishing compartments were completed and initial cuttings were under way as the year ended.

Naval Stores

In July, 1946, through a readjustment of Station boundaries, the Forest Management Division became responsible for naval stores research in progress at the Lake City (Florida) Branch. A review of the work of former years will not be made here but a brief summary of 1946 accomplishments is included.

A change in emphasis in the research program was made in 1946. During the war, high production was the goal. Now, with the gum naval stores industry in a highly competitive position, emphasis is being placed on studies of greater efficiency and lowered operating costs. A three-point program is being followed to accomplish this objective: (1) study of new turpentine techniques aimed at efficiency of operation, (2) development of high-yielding naval stores pines which, if grown in plantations, could yield twice the present amount of gum per tree and thereby reduce unit production cost, and (3) improvement of the mechanical efficiency of turpentining equipment.

In addition to the three-point program aimed at more efficient gum production, fundamental studies in tree physiology are continuing. Also, a study of integrating naval stores and timber production is being made to learn how a landowner can obtain the greatest profits.

Specific accomplishments in 1946 included:

(1) Accumulation of additional data substantiated earlier findings that bark chipping with acid stimulation gives high yields with less work.

(2) Pilot plant tests of this method, made with cooperators on a large production basis, showed 96 percent greater production than ordinary methods of chipping. The average net profit on the extra gum produced by this improved method was $1,365 per crop of 10,000 trees.

(3) The highlight for 1946 in the development of superior naval stores pines was the establishment of the first field plantation with seedlings from earlier controlled breeding experiments. The plantation consists of progeny from superior gum-producing trees crossed with other high-producing trees, from superior trees crossed with average trees, and average trees crossed with other average trees. The plantation is designed to furnish basic information on the inheritance of gum-yield traits as well as to develop the best possible "milkers" from cross breeding. Several hybrids of slash pine with longleaf and with loblolly are included in the new plantation.

(4) For the first time, cuttings from merchantable-sized longleaf pines were successfully rooted.

(5) A first test model of a combined hack and acid spray gun was produced. The new tool is intended to make chipping and acid application more efficient.

Forest Fire Research

One of the earliest activities at the Appalachian Station was in the field of fire studies. Fires were prevalent in 1921 when the Station was organized, and private, state, and federal protection agencies were inadequately financed. This situation emphasized the need for information on the damage caused by fires. Thus, the first fire studies consisted of surveys of fire effects.

Fire Effects and Economics

Fire effects studies have contributed in a major way to an understanding of fire control problems. Results of numerous fire effects studies were combined in 1941 into a damage appraisal system adopted by all the southern state fire protection organizations. This move has resulted in a significant improvement of the quality and comparability of fire damage data, an essential to intelligent fire control financing.

Fire control can be considered adequate when the total expenditures are such that costs plus losses are at a minimum. Increased expenditures beyond this point are not justifiable because they do not reduce losses sufficiently in contrast to costs. Determination of the justifiable expenditure is the basis essential to orderly fire protection planning. But the evaluation of fire losses (or benefits) is extremely complex.

Early experience in evaluating fire effects at the Station made possible a major contribution to the economic principles of fire protection in 1944 to 1946. The investigation developed methods and techniques for determining the most profitable fire control expenditure. Evaluations of all fire effects including those on timber, soil, water, wildlife, recreation, and industrial upset were made. Case studies of sample areas in mountains, piedmont, and coastal plain brought in the many variations of fire control problems.

Rate of Spread

Scientific fire control requires that facilities such as roads, trails, telephone lines, lookout towers, and manpower be located in the right places to bring cheapest and most effective protection to the forest values. Contributions to this field of fire planning have been of major importance since 1937.

A system of evaluating fuel types from the standpoint of rate of spread and resistance to control was developed in 1937 and 1942. The classification shows how fast fires will spread in each fuel and how much effort will be required to control them. Identification of fuels by this system enables proper consideration to be given to location of protection facilities to cover the more dangerous and difficult areas first. Knowledge of rate of spread by fuel types is of value to a fire dispatcher in calculating the action to take in suppressing fires. The information obtained from these studies formed a partial basis of federal fire control planning and is also used currently by federal and state agencies.

Detection

Studies of the visibility of smoke columns, begun in 1937, led to a series of valuable contributions in the field of physical optics and vision. Inasmuch as fires are detected by the keen eyesight of lookout observers, the success or failure of the whole protection system stands or falls on an understanding of smoke visibility. No one had ever worked extensively on the visibility of highly illuminated small objects such as smoke columns. The fundamental factors affecting their visibility had to be determined before the best system of lookout stations and visual aids to observers could be developed.

Distribution of illumination in retinal images was studied, and this led to the design of a practical and reliable eyetest for lookout observers (1940). No satisfactory test existed before this study was made. The present eyetest is used nationwide by fire control specialists. It found widespread use by the military services during the war. Fundamental studies of visual acuity (1944) have resulted in standards of smoke visibility distance. Recommendations have been made on how to space lookout stations under varying conditions of haze (1937). Two haze-meters were designed (1940), one each for mountain and plains conditions, by which accurate measurements of visibility distance can be obtained to guide in the manning of lookout stations. A polarizing filter was developed (1942) that enables an observer to look through haze, under some conditions, and facilitates smoke detection. Visibility studies were completed in 1946 with a series of comprehensive technical papers and bulletins on the fundamental and applied aspects of visibility measurement.

Fire Danger

Early in the history of fire research at the Station, some attention was given to the importance of weather on the incidence of forest fires. It was shown that certain types of weather had a pronounced effect on the build-up of fire danger.

Following a lapse of several years, intensified study of the variables of fire danger and their evaluation was begun (1937). A system was evolved (1938) of measuring the key factors of danger and integrating them by means of a meter on a scale of 1 to 5.

The development of this fire danger rating system and its subsequent use by state and federal protection agencies has probably done more to improve fire control than any other contribution of fire research. Fire danger rating systems, designed to measure when fire control forces are needed, effect savings by making such forces available for non-fire work when conditions permit. In order to get a highly practical and inexpensive system, special instruments had to be invented. One of these, the Appalachian Fuel Moisture Scale, is used widely throughout the United States and in several foreign countries.

FOREST ENTOMOLOGY, 1924-1946[1]

Initial forest insect investigations, in cooperation with the Appalachian Forest Experiment Station, date back to the summer of 1924 when Mr. A. H. MacAndrews established a tent by the Ranger Station at Lake Powhatan on the Bent Creek Experimental Forest. During that year biological investigations of forest insects indigenous to that area were begun. It was not until the spring of 1925 that Dr. F. C. Craighead, in charge of the Division of Forest Insect Investigations, Washington, D. C., arranged with Mr. E. H. Frothingham, then Director of the Forest Service field station at Asheville, N. C., to establish a forest insect field station there. During April of that year, Mr. R. A. St. George was assigned to that station and was made directly responsible for the conduct of the work. In company with Mr. MacAndrews, a site was selected on the Bent Creek Forest near the spot where the first building was subsequently erected.

Following Mr. St. George, the forest insect investigations were continued and enlarged upon by Drs. J. A. Beal, B. H. Wilford, and C. H. Hoffmann. Also notable contributions to the work were made by the following personnel: R. F. Anderson, W. L. Baker, R. E. Balch, W. E. Bramble, R. W. Caird, C. B. Eaton, E. C. Holst, B. J. Huckenpahler, H. R. Johnston, and R. J. Kowal.

Dr. Craighead's keen interest in fundamental research has been reflected in the character of the program of work carried on at the Asheville station ever since its inception and by the nature of many research publications by forest entomologists working under his guidance.

Major entomological problems which were studied intensively included the following: (1) ecology and control of the southern pine beetle; (2) tree injection to kill barkbeetles and to preserve wood; (3) control measures for termites; (4) powder-post beetle investigations; (5) biology and control of white grubs in nurseries. These and other miscellaneous forest insect problems incidental to the main program are discussed briefly below.

Southern Pine Beetle

Since the southern pine beetle, Dendroctonus frontalis Zimm., is one of the worst enemies of southern pines and since one of the most severe droughts during the previous 50 years was in progress, it is only natural that this insect was the center of the initial investigative studies.

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[1] Prepared by R. A. St. George, C. H. Hoffmann, and B. H. Wilford; Division of Forest Insect Investigations, Washington, D. C.

The extensive dying of pine from the combined effects of drought and insects, the growing importance of reforestation, and the imperative demands for assistance from southern timberland owners emphasized the pine-insect situation as one of greatest importance.

The initial experiments centered around the theory that unfavorable climatic conditions, chiefly drought, produce effects within the trees which make them attractive to the southern pine beetle and certain species of Ips barkbeetles. Experiments were planned to simulate the effects of drought on a group of shortleaf pine trees by trenching around several trees located on a knoll and covering it with canvas to shed water. It afforded an opportunity to study the subsequent growth, sap density of the phloem and leaves, soil moisture and temperature relations, and the susceptibility of the trees to barkbeetle attack. Dr. E. J. Kraus assisted in the plant physiological aspects of the problem, paying particular attention to the food reserves in normal and treated trees, and Dr. C. F. Korstian aided in making the sap density determinations and in interpreting their significance. Such was the beginning of the intensive forest insect investigative work at Bent Creek.

Later studies showed that a direct correlation exists between drought and subsequent barkbeetle attack; that barkbeetles were inoculative agents of bluestain spores in trees, and also create favorable conditions for the stain to develop; that the rapid death of the tree following barkbeetle attack is directly attributed to the bluestain fungi and yeasts, rather than to mechanical injury caused by girdling of the inner bark of the tree by the beetles; that the experimental study of the physiology of pines revealed the wood dries from the outer ring to the center of the trunk in areas infested with beetle galleries, and that the bluestain fungus (Ceratostomella pini) is closely associated with the stoppage of conduction and drying of the wood; that the broods in barkbeetle infested trees during epidemics are frequently adversely affected by excessive moisture conditions and by extremes in temperatures.

Extensive surveys of stand improvement work and other cutting operations showed that pine can be cut during the summer and yet not cause barkbeetle outbreaks, provided there is a continuous supply of slash and it is kept away from living trees. Other field studies indicate that epidemics of the southern pine beetle cause a change in forest composition from pine to hardwoods and that mixed pine-hardwood stands are less susceptible to attack than those of the pure pine type.

Wood Preservation

A thorough examination this year (1946) of standing trees, poles, and stakes impregnated with chemicals at the Bent Creek and Santee experimental forests from 1930 up through 1940 gave additional valuable information on the feasibility of wood preservation by such methods as stepping, capping, and banding. These methods, the so-called sapstream treatments of getting chemicals into trees, were developed at the

Appalachian Station, first in conjunction with barkbeetle control investigations, later during the studies of forest products insects. Some treatments of standing and freshly cut trees with preserving salts completely protected the wood from insects and decay, noticeably lengthening the useful service of the wood.

Owners of wood lots and others can utilize these methods to effectively treat non-durable woods for fence posts and rustic construction. Chemicals such as copper sulfate and chromated zinc chloride have been found satisfactory for this purpose when used at an injection dosage of one-half pound to one pound of the salt to one-half gallon of water per cubic foot of sapwood.

Earlier reports on the subject of sapstream treatments resulted in considerable active interest in research and in practical application of the methods in the Southeast and in Canada.

Termites

The information accumulated from termite control investigations carried out at the Appalachian Station was used to definite advantage in advising Army, Navy, and federal housing agencies on construction prior to and following our entry into the war. Several changes in the services' construction specifications were brought about partly through contributions resulting from these investigations, the most valuable one being the elimination of termite shields.

Hundreds of posts cut from trees impregnated with water-soluble salts were buried one-half their length in the ground to determine their resistance to attack by termites and decay. Many of these chemicals have given satisfactory service for a period of ten or more years.

Approximately 60 houses in Asheville have been experimentally treated with soil poisons to control termites. Certain by-product oils showed considerable promise when compared with standard chemicals recommended for this purpose.

Powder-post Beetles

Some studies on chemical control of and protection against powder-post beetles were carried on at Bent Creek in conjunction with biological studies of these insects. Chemicals such as orthodichlorobenzene, a 5 percent solution of pentachlorophenol, a mixture composed of 9 parts turpentine to 1 part of kerosene, and kerosene alone proved effective in checking infestations in seasoned wood products. The pentachlorophenol also served to prevent attack. Contributions from these chemical control investigations were used advantageously by the public and by private industries in peace as well as during war times.

Considerable data were collected regarding the relationship between the starch content of wood and powder-post beetle attack. Infestation varied in proportion to the starch content, being most severe as the quantity of starch increased.

White Grubs

Intensive studies for the control of white grubs in pine nurseries were carried out in the Carolinas from 1932-1938. Our knowledge regarding the biology of the genus Phyllophaga and distribution of the species was considerably increased, and a means for practical control was developed. Although acid lead arsenate proved effective for control of the grubs, the margin of safety between the least amount needed to kill the larvae in the soil and the maximum amount tolerated by the seedlings was found to be very narrow. The most satisfactory remedy consisted of injecting the soil with carbon disulfide. A soil injector was invented which made the application of this chemical practicable.

Miscellaneous Forest Insect Problems

Even though plans are evolved each year for carrying out long-time entomological projects, some of these studies often have to be curtailed on account of population fluctuations and other conditions. At the same time, however, frequently urgent new short-time forest insect problems arise in different forests. All through the years, forest entomologists at this Station have studied and reported on such problems involving injurious insects, their interrelationships with fungi and weather conditions in damaging the forest, and important information has resulted from these investigations.

Observations indicate that in some areas large losses of oak can be attributed to late freezes, while in other forests drought and late frosts, in combination with fungi and insect attack, cause marked deterioration. As a result of drought and Ips barkbeetle attack, some ten million board feet of southern pines were killed in the Gulf States in 1925. Hickory trees may become weakened by a rainfall deficiency and rendered favorable for brood development of the hickory barkbeetle. Excessive rainfall at the time of beetle emergence and while young larvae are present in the phloem, causes mortality to both stages.

As a result of fire studies, it is now known that infestations of certain barkbeetles and borers indicate in advance which fire-damaged trees will die, and that scorched foliage is more important than stem scar as an indicator of fire damage.

A study of turpentine borer damage showed heavy losses due to windfall, decreased gum production, and defects in lumber; also that such damage could be prevented by fire protection and by conservative turpentining methods. The locust borer, a serious pest of black locust, was found to be susceptible to spray emulsions, provided they were applied in the spring when the larvae reside between the bark and the wood.

Of unusual interest was the discovery of serious injury to the roots of eastern red cedar seedlings by the seed-corn maggot. Adequate control of this pest in forest nurseries is obtainable with miscible carbon disulphide.

During World War II, surveys were made and advice furnished to growers on the control of insects attacking cultivated goldenrod, which was planted to produce a supply of rubber for technical experimentation.

Recently considerable interest has centered about aphid epidemics on pine trees and their possible relation to tree diseases. Fortunately these outbreaks have been brought under control by natural insect enemies before the insects caused noticeable direct injury to the trees. A closely allied insect, a chermid, on the other hand, causes reduced growth and a drooping malformation of current shoots on small white pine trees. Ornamentals of value can be saved by the thorough application of a standard oil emulsion.

FOREST PATHOLOGY, 1925-1946[1]

Research in forest pathology follows three main lines: forest diseases, shade tree diseases, and the deterioration of forest products. The Asheville branch of the Division of Forest Pathology, established in 1925, has been engaged in all three types of problems, with major emphasis on the diseases affecting timber management.

With the chestnut blight sweeping through the southern Appalachians in the 1920's, the earliest work was directed at determining how long the dead trees would be useful for tannin extraction and for pulpwood. These studies established that the tannin content in dead trees drops little until the wood becomes appreciably decayed, and that wood would ordinarily be useful for tannin and pulp for about 30 years after death of the trees. This was invaluable information for the 16-odd chestnut tannin plants in the region. The accuracy of these predictions is attested by the continued operation of extract plants to the present time.

Coincident with the work on chestnut salvage went research into the performance and value of the Asiatic blight-resistant chestnuts, when planted over the range of the American chestnut. Thousands of plantings were made on old fields and other abandoned lands, and the great bulk of these failed. A few were made on good forest sites and fertile farm land, and most of these have succeeded. The Asiatics will not do well on poor sites, but where they can be planted on better soils they will provide nuts, fence posts, small poles, and other useful products.

Following the early work on chestnut problems, a comprehensive research program was inaugurated, aimed at reducing the extensive losses being caused by timber decays and canker diseases, and at discovering the causes of and the control for the many unstudied diseases of economic importance in the southern Appalachians. The rapid expansion of the southern pine paper industry, and later, the second World War, involved the Asheville branch in research on the deterioration of forest products. The spectacular epidemic vascular wilt of the mimosa tree, one of the most popular ornamentals in the South, drew attention to the shade tree disease field. The close of two decades of disease research finds the Asheville branch devoting major emphasis to the determination of the cause and control of extremely important little leaf disease of pine.

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[1] Prepared by George H. Hepting; in charge, Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, Asheville, N. C.

Timber Decays

The major decay losses in standing timber result from butt rot from basal wounds, butt rot from the parent stump in the case of sprouts, and top rot from natural wounds. Lesser decay losses result from pruning wounds and thinning sprout clumps. To determine the sources of these losses and practicable means for minimizing all of them required an extensive series of investigations.

Studies on hardwood logging operations throughout the Appalachians established the range in cull for the major species, the increase in cull with diameter and age, and clearly demonstrated that fire scars were by far the greatest single avenue for butt rot in the hardwoods. In old-growth oak of seedling origin butt rot can be reduced from the present average of 15 percent of the gross volume to 1 percent by the elimination of fire. A rotation age not to exceed 150 years will eliminate most of the top rot.

Analysis of the relation of fire wounds and decay to the whole problem of tangible timber losses from fire, showed that 45 percent of the money loss from fire in mountain hardwoods was due to decay in the standing timber that remained alive after the fire. A formula was developed, based upon the study of fire-scarred oaks throughout the mountain region, that permits an estimate of the volume of cull that will develop behind wounds of any given size over any given number of years after a fire. These results can be readily applied in making cull deductions in timber estimating, on timber sales, and in surveys.

In oaks of stump sprout origin the incidence of decay is high. Studies of thousands of trees in the coppiced forests of Pennsylvania, Virginia, and West Virginia showed 25 percent of the young oaks to be butt-rotted from the parent stump. The important discovery was made that while sprouts that arose a few inches high on the old stumps usually contracted the stump decay, sprouts that arose at or below the ground line seldom became decayed. Since the high-origin sprouts usually become the dominant ones in a clump, they should be eliminated early. Favoring low-origin sprouts before a stand is 15 years old will greatly reduce butt rot and will avoid large multiple sprouts later.

The estimation and prediction of top rot is one of the knottiest problems in timber cruising and in determining whether to cut or leave a given tree in cutting operations. Studies in oaks have provided fairly reliable means of estimating the volume of cull associated with rotten stubs, wounds, blind knots and other external indications, and these results are being used on National Forest timber sales and by the Forest Survey. Similar studies in pine have aided in estimating the amount of red heart associated with conks on the bole.

Research on decays in connection with special woods operations has produced many results of definite value: (1) Ten years of study of oak sprout clump thinning shows that removing one of a pair of companion sprouts is risky from the rot standpoint if the trees are larger than 3 inches in d.b.h., and the crotch is of the V-type, but the decay hazard is slight when the sprouts are smaller or are separated with U-type crotches. After 10 years only 54 percent of the 2.6- to 4.0-inch wounds and only 6 percent of the wounds 5.6 inches and wider had healed; (2) Pruning wounds on oak must not exceed 1.5 inches in width if the percentage of wounds infected with heart-rot fungi is to be kept under 10 percent; (3) Conky trees felled and the conks knocked off will regenerate new conks for 5 to 10 years if the fungus is a Fomes, but will produce new ones only sporadically for the first few years if the fungus is a Polyporus.

Canker Diseases

Nectria canker is damaging to black walnut and some of the northern hardwoods throughout the mountain region, and to the oaks in western Maryland and parts of West Virginia. It is common on small or suppressed yellow-poplar, but the cankers on this species heal out rapidly as size or vigor increase. Nectria is a minor problem on other species. Strumella canker is frequently damaging to oaks in Maryland, Virginia, and West Virginia. The idea that systematic eradication of cankered trees might ultimately result in greatly reduced infection is being tested by experiments started 13 years ago in heavily cankered stands in western Maryland. Cankered trees have been repeatedly removed on a 186-acre and an 11-acre tract, while adjacent areas serve as controls. These experiments indicate that in oak, new cankering by Nectria becomes very slight after a stand passes the age of 25 years, regardless of eradication, but Strumella infection continues. Eradication has proven costly and unnecessary against Nectria and ineffective against Strumella.

Cross-inoculations with Nectria from many tree species showed that there is a common species, N. galligena, that causes cankers on many species, a distinct species N. magnoliae that causes the cankers on yellow-poplar and mountain magnolia, and possibly a third undescribed species that causes the cankers on sassafras.

Increment borings made experimentally in sugar maple and in yellow-poplar of low vigor always resulted in Nectria cankers, while borings in white oak, scarlet oak, vigorous yellow-poplar, and white, pitch, and shortleaf pine produced no external defects. Internal defects will be determined in 1947 (10th year after boring).

Little Leaf Disease

The little leaf disease of pine is now established as the major problem in growing shortleaf, and in some places loblolly, pine over hundreds of thousands of acres throughout the piedmont and in the upper coastal plain of Alabama. Cutting practices recommended for these areas involve recognition of the disease and frequent early cuts to salvage the little leaf trees before they die. On the average they will die within 7 years of the appearance of the earliest symptoms. Research on the cause of little leaf has uncovered strong clues in the direction of inadequate nitrogen nutrition and the possible role of soil and root fungi. Foliar analyses of little leaf trees show them to be conspicuously low in nitrogen and calcium, and normal in amounts of potassium, phosphorus, magnesium, and boron. Application of nitrogen to the soil tends to prevent little leaf among healthy trees and induce recovery in diseased trees; and the heavy application of litter, which would be expected to cause a temporary diminution in available nitrogen, accelerates decline from little leaf shortly after application. Diseased trees have been eradicated each year for the past 3 years from a 1,000-acre tract in South Carolina. Thus far the incidence of new cases has been as high on the eradicated area as on the uneradicated. This experiment is also providing precise data on losses and on the silvicultural aspects of the disease, such as the effect on composition, regeneration of pine, and bark beetle attacks, over a large representative area.

Mimosa Wilt

The mimosa tree (*Albizzia julibrissin*), a species of high ornamental value and heretofore remarkably free from pests, was found dying of a wilt disease in Tryon, N. C., in 1935. The wilt has since spread to 75 localities and now occurs from Richmond, Va., to Troy, Ala., and is well on its way to killing out the mimosas in many southern cities. The cause was found to be a new species of Fusarium which does not affect any of our native southern forest legumes. Soil treatments and eradication have thus far failed to check the disease. However, a search for strains of the mimosa tree resistant to the wilt has produced a few trees, raised from seed, that are now 7 years old and healthy, despite having been inoculated for 3 successive years and then planted in infested field soil. Over 700 other seedlings given similar treatment died of the disease. Methods for rooting mimosa cuttings have been developed, and cuttings from the resistant trees are now being tested for wilt resistance.

Stains and Discolorations

The expansion of paper-making from southern pine and the use of these pines for newsprint made it advisable to determine the importance of blue stain and decay in southern pine pulpwood. Peeled wood stacked in the woods in the fall developed blue stain to the extent of one-third to one-half of the sapwood volume in one month. This amount of stain affected the color of the pulp, requiring more bleach than unstained wood for white paper, but did not otherwise affect the quality of the paper. Instances of extensive decay of pine pulpwood in as short a time as 5 months have been studied, under unsanitary yard conditions and poor piling. Information on proper practices to reduce or avoid such losses has been made available to the southern paper industry.

The death of pines following bark beetle attack, a major source of loss in the southern pinery, centered attention on whether the cause of death was the beetle galleries or the blue-stain fungi that the beetles invariably brought with them. Extensive inoculation experiments showed that the rapid death of bark-beetle-attacked trees was caused by the invasion of the staining fungi rather than by the girdling effect of the beetle galleries.

During World War II yellow-poplar veneer and lumber were in heavy demand by the aircraft industry. The wood of this species is often variously colored in the living tree, with the colored wood commonly making up to 50 percent of the total volume cut from some areas. Most of this material was being rejected on suspicion of weakness, thus greatly reducing the supply. Strength tests on hundreds of specimens, supplemented by microscopic examination and cultures, established that most of the discolored wood was sound and of normal strength, and only the brown-colored wood need be suspected of decay. Independent estimates state that this work raised the production of aircraft yellow-poplar veneer by 25 percent when this material was in critical demand, and helped assure the rejection of unsound wood.

Decay in Wood Aircraft

The use of many thousands of wood aircraft and gliders by the Army drew attention to deterioration problems in aircraft during shipment and in use. Visits to 28 Army airfields and many manufacturing plants disclosed the need for extra attention to drainage, both in construction and maintenance in parts of several models. The moisture that led to decay cases came from outside sources such as landing-gear splash, wash water, and rain, rather than from internal water of condensation. Measures to avoid decay in wood aircraft were summarized in a special release and in an article in the Aero Digest, and the information was directly funneled to the Army fields by the A.A.F. Air Service Command.

Miscellaneous Forest Diseases

A new lethal vascular disease of large sugar maples in the Pisgah National Forest, called sapstreak, has been killing many trees in one locality. Experiments have demonstrated the cause of this disease to be a form of the sapstain fungus Endoconidiophora virescens, which enters through wounds and develops in the sapwood of otherwise healthy trees.

A new pine disease, called pitch canker, caused by a form of Fusarium lateritium, has appeared in parts of the Southeast. The cankers are very resinous and kill twigs and leaders of several species. Promising experiments are under way, testing this fungus as a stimulant to gum flow in naval stores operations.

A twig blight of major importance to the commercial production of ornamental hemlocks was found to be caused by the 1-cycled rust *Melampsora farlowii*. The life history of this fungus and effective control measures, involving spraying during May and June, were worked out in a single season. A new species of Rosellinia was described, causing a hemlock needle disease in North Carolina.

Repeated thinning of the white pine plantations on the Biltmore Estate has caused a marked build-up of the butt-rot fungus *Fomes annosus*. Unthinned stands had very little butt rot. Other butt rots in the Biltmore white pines were caused by *Polyporus schweinitzii* and *P. circinatus*.

Service

Heavy demands have been made on the time of pathologists for service work. This service was extended to all camps doing forest improvement work in the Appalachian region during the CCC program. Currently about 200 requests per year are being handled for examination of specimens, field visits, and miscellaneous service to forest and shade tree owners, nurseries, the Forest Service, National Park Service, T.V.A., S.C.S., and the States.

WATERSHED MANAGEMENT, 1931-1946[1]

In watershed management research we are finding out how foresters and land managers can best discharge their responsibilities as custodians of water resources. Less is known about water than about any other important product of the forest, principally because we lack observational data on which to establish a scientific basis for managing water as a natural resource. It was in recognition of this need for basic data that watershed management investigations were developed at the Southeastern Station. The original Streamflow and Erosion Investigations, first begun in 1931, have since expanded to become the present Division of Forest Influences.

Water has a commanding place in the economy of the southern mountain region. For many sections the local commodity value of water far exceeds the total value of harvested timber and other wood products. The southern mountain region is the source of water supplies essential to the greatest aluminum and textile industries in the world. An expanding paper and rayon industry is continually looking for additional water supplies. Municipal expansion has already led to rivalry for watershed areas. Hydroelectric power developments rank among the foremost of the Nation. Sportsmen from the great population centers of the East are making increasing and more exacting demands on the streams for recreational uses.

Notwithstanding their importance in the economy of the region, the watersheds of the southern mountains have suffered much from mismanagement, from indiscriminate cutting and burning, from soil depleting types of mountain agriculture and grazing. There has been a progressive deterioration of water resources as a result of land exploitation over a period of more than a century. Reduced water quality is evident in the sediment and pollution now carried by the streams. Decreased water supply is evident in more irregular streamflow and in the diminution of ground water reserves. Floods are of frequent occurrence with losses to crops and livestock and destruction of fertile valley land. Stream channel control is becoming increasingly necessary to prevent cutting away of valuable land, loss of roads and bridges, and the debouchment of rubble debris into the valley land below.

Research Procedure

Field investigations have been centered at the Coweeta Experimental Forest in Macon County, North Carolina. This 5600-acre completely forested area was selected specifically for water resource management research. Here are located 36 small drainages with continuous flow, each one suitable as an independent experimental unit. The average annual rainfall of 70 inches is well distributed throughout the year. The soils are relatively deep and permeable but water tables are sufficiently close to the surface to be observed in shallow wells.

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[1] Prepared by C. R. Hursh; in charge, Division of Watershed Management Investigations, Southeastern Forest Experiment Station.

Experimental procedure includes for each watershed, first, a period of observation of streamflow, precipitation, temperature, water table fluctuation, and a study of existing plant and soil conditions. This necessitated for each drainage the installation of stream measuring devices, weather stations, and observation wells. From these records we are able to compare the amount of rainfall and runoff for each drainage. The period of standardization requires about 5 years, during which streamflow and other essential water cycle characteristics of the watershed become known. Changes in the vegetation cover carried out under carefully controlled experimental procedures are then made and the same streamflow and other measurements are continued in the same manner as during the first period of observation. By this experimental plan accounts are kept of the continuous water economy of the experimental watershed both before and after changes are brought about in the vegetative cover. From these accounts it is possible to determine the effects of the land use changes on the yield and quality of water from the experimental watershed.

Experimental Watershed Studies

Effect of Vegetation Removal

One of the principal questions that has confronted the forest manager in the past is the effect of cutting forest vegetation on water quality and water yield. As a pilot study of this problem, all major tree and shrub vegetation over 0.5-inch diameter on a complete watershed was cut down, with a minimum of disturbance to the forest floor. This type of cutting was carried out on two separate experimental watersheds. On a third watershed, cutting was carried out on a narrow streambank strip only. On one watershed that was completely cut over, the coppice stand was allowed to return unmolested; on the other, the sprouts were removed in midsummer.

No impairment of the water quality appeared. A marked increase in water yield followed vegetation removal. This increase in runoff from the completely cut-over areas amounted to about 65 percent for the first year, and a significant increase has persisted each year since cutting. On the watershed where only the bank vegetation was removed, there was a definite increase in streamflow which resulted in an almost complete disappearance of the usual diurnal fluctuation occurring during the summer season. The amount of increase was about 20 percent. It is concluded from the above studies that watershed management calls for vegetation that transpires a minimum of water but maintains optimum soil structure for infiltration and storage.

Mountain Agriculture

The effects of agriculture on streamflow were studied on a complete watershed which was cleared and partly planted in corn. Results showed that favorable structure of forest soil remains for a period of about two years after clear cutting and cultivation under the soil conditions studied. Very little change in streamflow took place the first 2 years - as long as original structure of the surface soil remained. After the third year, reduction of organic material and tilth of the soil became increasingly evident; storm runoff was greatly increased; flood peaks increased from 4 to 10 times; erosion sediment carried by the stream increased 500 to 1,000 times as compared with similar storms. Unless very conservative agriculture is practiced, exceedingly unfavorable watershed conditions are created by clearing and cultivation of steep mountain slopes.

Woodland Grazing

The effects of woodland grazing were also studied on a drainage area basis. Here a forested watershed was subjected to excessively heavy browsing by beef cattle during the months of May to September. Heavy trampling took place during the first season, reducing the porosity of the original 6 inches of surface soil from 5 to 15 percent by volume. As palatable forage became reduced, cattle restricted their movement over the area, but progressive depletion of the soil continued, due to a damage of the natural surface conditions. Some changes in streamflow and surface soil movement appeared, and these changes are becoming progressively more conspicuous each year. It is concluded that heavy trampling and browsing of woodlands is definitely unfavorable to watershed values.

Effects of Burning

A preliminary study of the effect of fire was carried out on a forested watershed which was subjected to a single severe spring burn. Other than a slight temporary change in the pH of the stream water, no changes in runoff or in the amount of sediment were evident. In this burn the litter on the forest floor was completely consumed, and 30 percent of trees up to 6 inches in diameter were killed. A heavy growth of herbaceous plants and sprout growth appeared the first season after burning. Under the conditions of the experiment the deep clay soil was quite moist at the time of burning. Consequently, the burn did not greatly affect the soil below the immediate surface. As a result the normal soil structure and biological activity that govern infiltration and water storage in the soil are not significantly changed. The study to date is quite limited as to application and must be repeated on areas of thin soils and other conditions of aspect, topography, vegetative cover type, and frequency of burn. Observations elsewhere in the region, not on an experimental watershed basis, indicate that on certain types of thin shale soils heavy burning does cause severe storm runoff, erosion, and stream turbidity.

Effects of Logging

The effect of logging on water quality and yield was studied through a timber sale carried out on a complete experimental watershed. Logs were skidded down the natural drainage channels by horses, in keeping with local logging practices. Also a temporary access road for trucks was cut into the area. Some changes appeared in the amount of storm discharge in the stream as shown by the stream hydrograph. Of more significance are the large amounts of eroded material from the skid roads that appeared as sediment in the stream carried during storm periods. Better attention to the location, construction, and maintenance of skid trails and roads, and further improvements of logging methods are necessary to preserve water values. It is apparent that more time spent in location, construction and maintenance of skid trails during logging operations will pay large dividends in preventing erosion and maintaining water values. This study will be continued for the purpose of finding out the degree of water quality impairment caused by logging, and the length of time to which changes in water quality will persist after logging. The principal conclusion reached so far is that present local practices in the southern mountains are decidedly undesirable on watersheds of high water values for municipal, industrial, or recreational uses.

Interpretation of Streamflow

Due to particularly favorable rainfall, soil, and topographic conditions for watershed studies in the southern Appalachian mountains, progress was made in both fundamental and applied hydrology in a much shorter period of time than was first anticipated. Research findings at once helped to clarify certain controversial questions and established a sounder basis for understanding forest-streamflow relations. For example, the general shape of storm hydrographs from undisturbed forest areas during short intense storms resembles the shape of hydrographs produced by surface or overland storm runoff from relatively impervious land surfaces. Hydrologists interpreted this as meaning that there was inadequate infiltration of rainfall into the forest soil that resulted in surface storm runoff. Results of the Station's early studies showed that rapid rises in streams from forested areas are due almost entirely to outflow from rain that has fallen directly into the stream channel and are not due to lack of infiltration into the forest soil. By establishing the exact contributions of channel precipitation to runoff on a watershed basis, it was possible to clarify a misinterpretation that was one of the obstacles to the mutual understanding of forest-streamflow relations by both engineers and foresters.

At the same time it was also observed that considerable increase in streamflow not accountable for as channel precipitation does take place from undisturbed forest areas during long continued rains. By studying a large number of hydrographs from different experimental watersheds on the Coweeta Forest, it was found that the increase in storm water was due to both channel precipitation and to a form of subsurface storm flow, the nature of which had never been clearly demonstrated previously. Movements of the water table as recorded in observation wells were employed to establish the fact that the rainfall first entered the soil and then moved laterally through the porous upper soil layers to the stream channels in time to contribute to the storm runoff. The runoff was thus shown to be intermediate between overland storm flow and ground water seepage from the underground storage usually supplying the normal flow of streams during non-storm periods.

The above researches furnish a basis for a more realistic interpretation of forest-streamflow relations in terms of watershed storage than was possible before experimental data became available. They made it possible to explain stream behavior through the separation of streamflow on the basis of the source of the water - (1) from temporary surface detention, (2) from temporary subsurface detention, and (3) from more permanent ground water storage. This separation is necessary for interpreting the effect of different land use practices on stream behavior, or for comparing the effects of watershed treatments.

Of special significance from the standpoint of fundamental hydrology are the findings of the Station relating to the annual balanced water economy of small watersheds. These findings substantiate the theory that in humid climates precipitation recharge of a watershed for any one year should tend to equal the discharge from the watershed as runoff, transpiration, and evaporation, together with changes in the amounts of soil moisture and ground water stored on the watershed. Data for the substantiation of this theory as a sound hypothesis were published as a part of the Station's regular watershed studies.

Practical Applications

Municipal and Industrial Watershed Management Research

These research results find ready application in the practical management of municipal and industrial watersheds. It has been shown, for example, that cutting of trees may be carried out on forested watersheds without jeopardizing water values if proper precautions are taken. The common belief that unfavorable water yield will follow the disturbance of the original forest has arisen because land clearing for cultivation, heavy grazing, or heavy burning has generally resulted in reduced watershed values. Conclusive experiments have shown that cutting timber in a way that leaves the forest floor undisturbed will actually result in an increase in water yield in the southern states where the high summer temperatures favor excessive transpiration and evaporation.

On the other hand, it has also been shown that careless logging will jeopardize water quality through added turbidity and sediment. Further observations indicate, however, that this is a secondary problem which can be overcome by better harvesting techniques. The above findings apply particularly to a municipal or industrial watershed where shortages of water supplies frequently occur during the summer months. In such cases it is evident that cutting with minimum disturbance to the forest floor will be beneficial in increasing water yield. These findings clear the way for a more realistic program of multiple use. Research has pointed out the feasibility and even the desirability of harvesting timber products, which are now withheld from exploitation, on important areas where water is of primary importance.

Contributions to Flood Control Programs

On the basis of the early results from watershed studies, the Station has been able to assist in the practical solution of flood control problems related to land use. The coordination of a land use and a flood control program for the upper French Broad River was made possible by basic data obtained through experimental watershed studies. With these data it was possible to work out a uniform classification into which all lands in the region could be classified with regard to their capacity for infiltration of water into the soil. This classification provided a basis for common understanding by engineers, foresters, and agriculturists of specific land classes and the hydrologic significance of each class in local flood control problems.

Soil Stabilization

Although soil stabilization has not received major attention as a research problem, such investigations as were made contributed very definite results that found ready application. A number of studies were carried out along lines of naturalizing and stabilizing soil exposed by engineering works, such as railroad fills, roadbanks, earth dams, and borrow pits. The principal findings led to widespread interest in the use of mulches on infertile, dry and unstable soil. Mulches were first tried out in 1932 to protect seeded banks from becoming broken down by freezing and thawing during the winter months. It was then discovered that local weed and litter mulches served one of their greatest values in introducing and protecting indigenous plant species. Also the use of mulches provided a maximum of moisture protection together with a maximum stabilizing effect and physical improvement to soil, at a minimum cost. These findings were subsequently adopted by State Highway Departments, railroad maintenance engineers, and others, and have been widely used throughout the country with such modifications as are required locally.

During the years 1931 to 1934, preliminary tests of methods were made for control of gully erosion on abandoned farmland, and for the control of erosion on banks and fills created by the construction of mountain highways and roads. Subsequently these studies were transferred largely to the Soil Conservation Service, and the Watershed Protection Section of the Tennessee Valley Authority.

Experiments in soil stabilization methods served as demonstrations of inexpensive erosion control measures for other agencies concerned with action programs in soil conservation. As a result of these early studies the Station has since been constantly called upon to act as consultant on practical erosion control problems.

Studies of the Effect of Trees on Local Climates

Investigations of the effect of complete or partial removal of vegetation on the local climate have not been given a major consideration in the Division program. No permanent staff members have ever been assigned to the project. The only emphasis given has been in the Copper Basin where smelter fume damage provided an unusually favorable opportunity for comparing the local climates of contiguous bare, grassed and forested areas. There the project was carried out incidental to the comparative watershed studies in progress in these same vegetative zones. The study substantiated earlier reports which pointed out the marked effects on local climate brought about by the partial or complete removal of vegetation. Fresh emphasis was put on the influence of the presence or absence of leaves in a deciduous forest upon local temperatures and wind movements. The investigation also indicated the possibility that vegetation over large areas affects temperature of the land surface and the associated lower atmosphere, and this in turn may affect precipitation.

Limited observations on the effects of cutting on local climate have also been made as a part of watershed studies on the Coweeta Experimental Forest. The results, so far as they have gone, only substantiate the Copper Basin findings.

Integration of Forest Resources Management

The ultimate goal of the Station's watershed research program is to discover and establish a sound and practical basis for the management of forest land in the interest of water resources. Although the relative importance of specific problems may not be the same for different sections of the Station's territory, research problems in water resource management all relate directly to the use of land. Practical application of research findings will come about through the improvement or change in land use practices. Hence the real problem in water resource management is to determine and understand the relation of different land use practices to water, and ultimately to apply this knowledge to land management designed to restore and maintain favorable water supplies. As the facts of forest-streamflow relations become better known, they will be integrated into a forest management program directed toward the maximum utilization of all forest resources. In this integrated picture the utilization of one forest product will be carried out without jeopardy to other forest products. What we are finding out about water will expedite this broad approach to practical forest management.

U. S. WEATHER BUREAU'S FIRE-WEATHER DISTRICT EIGHT, 1932-1946[1]

History

During the winter of 1932, at the request of fire-protection agencies, the Weather Bureau established a fire-weather forecast center at Asheville, North Carolina, to serve the southern Appalachian area. Thirteen weather stations were installed at strategic locations throughout the proposed district. These stations were manned by personnel employed by the fire-protection agencies, and daily weather observations were taken and reports made to the forecast center.

The first fire-weather forecasts were issued during the spring fire season of 1933 and applied to only limited areas in the southern Appalachians. In general, the forecasts were for protection areas in extreme southwest Virginia, the mountains of western North Carolina and eastern Tennessee, and the mountains of northern Georgia and northwestern South Carolina.

Expansion

The fire-weather forecasts proved helpful for fire prevention, presuppression, and suppression activities in the forests, and requests were received for the service to be furnished to additional protection areas in the vicinity. This expansion has continued until District 8 today furnishes fire-weather forecasts to the principal forest areas in North Carolina, South Carolina, Virginia, West Virginia, and in portions of Georgia, Kentucky, and Tennessee where intensive fire control measures are found necessary. This area includes 100,213 square miles of protected forests, with a proposed increase to 127,800 square miles.

Protection Area's Value

This fire-weather district is one of the principal timber-producing sections of the United States, in terms of rapid growth. Protected forests cover approximately 50 percent of the total land surface. The climatic and topographic influences favor abundant reproduction and growth of valuable timber, ranging in species from spruce and temperate zone types to southern pines and cypress. The Southeastern Experiment Station estimates the value of the timber resources at nearly 2½ billion dollars. Industries associated with timber production and forest products in this district furnish a livelihood for the second largest group of persons in the manufacturing field.

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[1] Submitted by I. R. Tannehill; Chief, Synoptic Reports on Forecasts Division, Washington, D. C.

Techniques

Current weather reports from stations operated by protection agencies are used in conjunction with surface and 700-millibar weather maps, winds aloft charts, and radiosonde graphs to secure an accurate, 3-dimensional picture of present weather. These data are analyzed and evaluated in terms of future weather for each protection area. The forecasts are written in detail for those weather elements that have the greatest influence on forest inflammability. Each qualifying adjective and adverb in the forecast has a specific meaning as defined in "Fire Weather Terminology, 1940." Three types of forecasts are issued:

1. Daily forecasts, based on the 10:30 a.m., synoptic data and related charts. (These forecasts cover the remainder of the current day, the following night, and the succeeding day.)
2. Four-day "extended forecasts" (outlooks) are issued each Tuesday and Friday. Due to the period of time to which they apply, these forecasts must be more generalized than the daily forecasts.
3. Special forecasts are prepared for "going" fires whenever a request is received. This kind of forecast is usually requested when a large fire develops and detailed information is needed about future weather at the fire.

Distribution

The forecasts are distributed through 80 outlets by telephone and telegraph. Most of the recipients are district administrators of national and state forests, who in turn relay the forecasts to all concerned with fire control on the districts.

Use of the Forecasts

The uses to which the forecasts are put depend primarily on the skill of the forester in applying the information to his administrative unit. Some of the uses are as follows:

1. Projecting current fire danger rating into the future.
2. Determining when to issue or cancel burning permits.
3. Determining when logging and lumbering operations can be resumed or suspended.
4. Determining when to open or close recreational areas to public use.

5. Determining when and where to employ forest guards, patrols, work crews, etc., to best advantage.
6. Determining when to man fire towers.
7. Determining when to grant annual leave and compensatory time.
8. Determining when to request railroad companies to place fire screens on locomotives.

Value of the Service

Based on reports received from the various agencies receiving the forecasts, savings effected by the application of the forecasts vary from a quarter of a million dollars per year, during seasons when few fires occur, to one million dollars or more per year during a season when frequent or large fires develop. (Such seasons seem to average about once every 4 or 5 years.) Cost of complete operation of the service is estimated at $15,000 per year.

In comparison with the expenditures of the fire control organizations (according to statistics compiled by the Southeastern Forest Experiment Station), the fire-weather service is spending $1.00 for every $389.00 spent for fire suppression alone on the District.

The Weather Bureau is constantly on the alert to adopt new techniques which will increase the accuracy of all of its forecasts. In the fire-weather service, every attempt is made to issue weather forecasts which will be applicable to the areas under protection and include specific information concerning the wide variety of meteorological conditions which influence fire protection and control.

FOREST SURVEY, 1936-1946[1]

General

The Forest Survey started at the Appalachian Forest Experiment Station in April 1936. Emphasis centered upon field inventories, growth, drain, and resource analysis until the spring of 1942, when practically the entire effort of the Survey staff was shifted to war activities, chiefly timber products investigations for the War Production Board. This diversion to other activities continued throughout 1945.

Inventory

Field inventory work, using a line-plot system of survey, began in South Carolina in July 1936. One unit of the State had already been completed by the Southern Station; the remaining two units were completed by December of that year. During 1937 and 1938 all of North Carolina was inventoried, and in 1940 Virginia was completed. For the first time an accurate estimate of forest area and timber volumes was available for these three States, which combined have over 44 million acres of forest land supporting almost 100 million board feet of saw timber.

In conjunction with this inventory a complete set of tree volume tables was prepared, by species and diameter-class, in both board feet and cubic feet for each of the twelve survey units in the three States. These tables have had wide circulation and usage both within and outside the Forest Service.

Growth

In conjunction with the field inventory, increment cores were obtained from about 80,000 sample trees to serve as a basis for estimating annual growth. As rapidly as each survey unit and state was inventoried, growth computations were made, thus providing for the first time a reliable estimate of the annual yield of wood in each state and part thereof. These estimates have been prepared each year through 1945, and when used in conjunction with estimates of drain, have provided an indication of trends in growing stock supplies -- data of immense value to federal and state officials and to private industry.

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[1] Prepared by J. W. Cruikshank; in charge, Forest Economics Research, Southeastern Forest Experiment Station.

Drain

Immediately following the completion of the field inventory in each state, an intensive field canvass was made to find out the quantity of timber consumed for forest products and domestic use. Field studies of woods waste resulting from logging were a part of these drain studies. Methods of obtaining the amount of timber cut into lumber have varied. Originally the Forest Survey canvassed all sawmills independently of the Bureau of the Census, then the Survey cooperated with the Census by editing forms and checking delinquent mills, and in more recent years the Survey has undertaken the direct field canvass, under the direction of the Bureau of the Census, in intensities ranging from a sample of about 25 percent of the mills to 100 percent of all mills, as for 1942 production. More accurate information on timber use has resulted.

Each year the Survey has obtained wood consumption records from all primary non-lumber plants in each of the three states surveyed and in addition has compiled annual records of hewn crosstie and pole and pile production. Special fuelwood studies, to determine total consumption, have been made in each state. Mine timber requirements of coal mines in Virginia, West Virginia, and Kentucky were also the subject of a special investigation. Data have been summarized each year, through 1945, to provide an estimate of total drain by states, survey units, species group, and commodity. Information obtained on these drain surveys proved invaluable when the Survey staff shifted to forest products investigations for the War Production Board.

Resource Analysis

Accomplishments in this field include the publication of multilithed reports on the forest resource, growth, and drain for each survey unit, several multilithed reports on special subjects related to the forest resource, two printed comprehensive state reports, and several articles in outside publications (see attached list of publications). The demand for Survey reports has been heavy, and thousands of copies have been distributed in response to requests.

Even before reports were prepared for the Carolinas and Virginia, requests for Survey information began to be received from foresters, land-use planners, and wood-using industries. As the work of the Survey became better known, the number of such requests greatly increased and their handling became an important part of the work of the staff.

Forest Survey data were used in the preparation of the Forest Service Report to the Joint Congressional Committee, of the reports of the National Resources Committee, and in the more recent Reappraisal Project of the Forest Service. Other federal agencies such as the Bureau of Agricultural Economics, the Soil Conservation Service, and the

Tennessee Valley Authority have requested special tabulations of Survey data to aid in analyzing local land-use problems. The State Forest Services and Extension Services have also used Survey information as a basis for developing their programs and as a means of presenting their forest problems to the public.

Pulp and paper companies have relied on Survey estimates in the determination of possible mill locations and have consulted with the Survey staff regarding the desirability of proposed sites from the aspect of timber procurement. Established pulp companies have requested special tabulations to aid them in appraising the wood supply situation in their procurement territory and to serve as a guide in their land acquisition programs.

Other Activities

These include a great variety of endeavors, such as an economic survey of the timber resources of Cherokee County, N. C., in cooperation with TVA, FSA, and the Nantahala National Forest; a study of forest taxation in North Carolina in cooperation with the Forest Taxation inquiry and the North Carolina Classification Amendment Commission; and a special report on the timber supply situation in the Sumter area of South Carolina, in cooperation with Region 8 and the State Forester. Of much greater magnitude, however, were the following:

Postwar Planning: One member of the Survey staff acted as Secretary of the Interbureau Committee on Postwar Planning, Appalachian Region, and assisted the chairman in the organization of state working groups, in the preparation of an atlas of agricultural and forestry information, in the preparation of the forestry section of state postwar programs for agriculture, and in the preparation of a regional postwar planning report. This was about a 2-year project.

Eastern Kentucky Highlands Project: 1945 brought to a close our cooperative studies with the University of Kentucky of land-resource management in the Eastern Kentucky Highlands. These studies were made in a sample area within Breathitt, Knott, and Perry Counties, and had as their purpose to learn the present and potential contribution of land resources to the well-being of the people. The five principal reports resulting from these studies were: (1) management of forests in the Quicksand area of the Kentucky Highlands; (2) timber marketing in the Eastern Kentucky Highlands; (3) farm production, labor supply, and family income in the Quicksand area of the Kentucky Highlands; (4) the sociology of land use in the Breathitt area of Eastern Kentucky; and (5) farm and forest resources in the economy of the Eastern Kentucky Highlands. Division personnel contributed authorship in three of these: the first, second, and fifth.

Reappraisal Project: As part of a nation-wide reappraisal of the forest situation made by the U. S. Forest Service, nearly three man-years of time (exclusive of that contributed by the Station Director) were spent in preparing statistical tables and analyses concerning the forest resource. Reappraisal tables were prepared for South Carolina, North Carolina, Virginia, West Virginia, and Tennessee showing forest area by ownership and stocking class; timber volumes by species, ownership, and stocking class; current annual growth and commodity drain. In addition field checks were made to determine logging and manufacturing waste, and state tables were prepared summarizing the data. Another important phase consisted of computations to show the amount of growing stock needed to maintain present commodity drain, the growing stock 20 years hence if cut continued at present level, and the annual cut which could be maintained from present growing stocks.

Cooperation with Bureau of Census: Every year since 1938 the Division has cooperated with the Bureau of the Census to obtain annual estimates of lumber production. This cooperation has assumed various forms, at first consisting of merely editing the reports, but by 1943 it had grown to the point where the Division, with the help of TVA and other personnel in the Station, made a 100-percent canvass of all mills (about 15,000) in the Station territory. Since then the Bureau of the Census has assumed a greater share of the cost of the annual canvass, although the field work is done by the Division, and the annual sample has included up to 65 percent of the total number of mills.

Requirements, Production, and Supplies: Early in 1942 the Forest Survey started active cooperation with the War Production Board in the collection of forest products statistics and the preparation of special reports dealing with the forest products industries. This work has continued into the reconversion period under the auspices of the Civilian Production Authority. Major emphasis has been upon the preparation of a monthly estimate of lumber production and stocks and upon monthly and quarterly reports on factors affecting lumber production, but during the war years a great variety of reports were prepared. Our major statistical and written reports to December 31, 1945, were as follows:

1. Monthly estimates of lumber production.
2. Monthly estimates of sawmill and concentration yard stocks.
3. Factors affecting lumber production (quarterly and monthly).
4. Monthly reports on production, shipments, and stocks of yellow-poplar aircraft lumber.
5. Survey of the chestnut extract industry.
6. Production of hemlock tanbark in the Appalachian region.

7. Production of chestnut oak bark.

8. The supply and industrial consumption of hardwood species suitable for aircraft veneer.

9. Factors affecting production of yellow-poplar aircraft veneer in the Appalachian Hardwood region.

10. The supply of white oak available for ship timbers.

11. Log inventory at large sawmills in the coastal plain and piedmont of the Carolinas and Virginia.

12. Logging camps, estimated number and employment.

13. Movement of rough forest products by truck.

14. The log and lumber truck situation in the Appalachian Hardwood region and the Pine region of the Carolinas and Virginia.

15. Survey of dry kilns to determine number, capacity, equipment, and degree of utilization of kilns.

16. Field survey and individual report on pulpwood procurement at each mill in Station's territory.

17. The fuelwood situation in the Carolinas, Virginia, West Virginia, and Kentucky, 1942, 1943, 1944.

18. Idle small sawmills in the Appalachian Hardwood region and the Pine region of the Carolinas and Virginia, 1943.

19. The communication and power pole situation in the Carolinas.

20. Production and inventories of poles and piling in the Carolinas, Virginia, West Virginia, Kentucky, and Tennessee.

21. Power units at small sawmills in the Appalachian Hardwood region.

22. Production, distribution, and pricing practices of small sawmills cutting hardwoods in the Southern Hardwood region of the Carolinas and Virginia.

23. Production, distribution, and pricing practices of small sawmills cutting hardwoods in the South Central Hardwood region of Kentucky and Tennessee.

24. Production, distribution, and pricing practices of small sawmills cutting hardwoods in the Appalachian Hardwood region.

25. Production of log-run yellow pine under MPR 19A in the Appalachian Hardwood region.

26. Crosstie production trends in the Carolinas, Virginia, West Virginia, Kentucky, and Tennessee.

27. Wood waste available for conversion to alcohol in the Tarboro area of North Carolina.

28. Wood waste available for conversion to alcohol in the Durham area of North Carolina.

29. Wood waste available for conversion to alcohol in the Raleigh area of North Carolina.

At the close of the war a reinventory of the southeastern states began in South Carolina. Major activities included planning and starting inventory surveys, revision of growth prediction procedures, procurement and computation of forest drain data, and preparation of survey reports. The use of aerial photographs and modern photo-interpretation should permit a reinventory of great local accuracy at lower cost. Cooperation was continued with the Bureau of the Census in a field canvass of sawmills to obtain 1945 lumber production. Reports on monthly lumber production and stocks on hand were also continued for the use of the Civilian Production Authority through 1946.

FOREST GRAZING, 1940-1946[1]

Cattle have been grazing in the coniferous forests of the coastal plain since the time of the Spaniards. It is here on the coastal plain (where the effects are quite different from those among the mountain hardwoods) that the Station has concentrated its grazing research. The work since 1940 has been carried on cooperatively with the Bureau of Animal Industry and the Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA, and North Carolina and Georgia State Agencies. The primary object is to develop better grazing systems on native range and determine how grazing can be fitted in to best advantage with good timber management. The view is taken that forest grazing should not seriously interfere with timber production because possible income from timber is greater, no doubt, than that from grazing. Enough research in forest management and grazing has been done already, it seems, to indicate this. Therefore, forest areas should be managed so they will restock to trees and produce about the maximum timber crop. Where this is done the available forage in the forest will gradually decrease, of course, but with cuttings, fire lanes, and controlled burning, enough forage should always be available for some cattle.

Research results during the past six years indicate definite values in forest grazing on the coastal plain. Grazing not only produces some annual income to the forest owner but can be beneficial in some timber types in tree seedling establishment and early growth, and in fire hazard reduction. There is strong possibility also that it can be used as a silvicultural tool in checking hardwood invasion in areas where pines are desired. Contrary to common belief, it now appears possible under good management to grow more timber with grazing than would be possible without it.

Forage Types

Most of the studies in forest grazing are located in two forage types in the coastal plain, in the wiregrass type at Alapaha in Georgia, and in the switchcane or reed type at Wenona and Hoffman Forest in North Carolina. These are the two main forage types in the territory of the Southeastern Forest Experiment Station. The wiregrass type covers most of Florida, the coastal plain of Georgia, and extends about one-third of the way into South Carolina. Small areas of wiregrass are found also in North Carolina. The switchcane type occurs mainly in the coastal plain of North Carolina, where it covers in some degree about 25 percent of the area. In some places brush has invaded the switchcane areas to such an extent that little forage remains.

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[1] Prepared by H. H. Biswell; formerly in charge, Forest Grazing Research, Southeastern Forest Experiment Station.

In the wiregrass type the principal forage plants are pineland threeawn, Curtiss dropseed, and bluestems. Many other species make up small amounts of forage. On some areas a single species of the three principal plants may form an almost pure stand, while in other areas the three species are well intermixed. In the switchcane type a single species, the switchcane or reed, makes up most of the forage.

Wiregrass range provides reasonably good grazing in spring and early summer but only fair grazing after early July. During winter the wiregrass needs to be supplemented with concentrated feeds. The switchcane type is only slightly different. It furnishes reasonably good grazing throughout the summer, but supplemental feeds are needed during the winter.

Management of Range Cattle

Out of several systems or ways tested for handling cattle on a yearlong basis, two have proven highly satisfactory. One is to keep the cattle on range yearlong and supplement the native forage with concentrated feeds during the fall and winter. The other is to keep the cattle on range during the spring, summer, and fall and move them into a dry-lot for six or eight weeks during winter where they are fed harvested feeds. Although both systems work well, the latter has proven slightly more profitable and practical than yearlong grazing. In some cases, however, it may not be possible to grow feeds for winter, in which case it would be necessary to keep the cattle on range and feed supplements. In North Carolina it has been possible thus far to grow corn for ensilage and hay, and in Georgia it has been profitable to grow sugar cane.

Supplemental Income From Grazing

Even where forest areas are managed for maximum timber production, it seems possible to graze for supplemental income. This does not take into consideration any increased values from fire hazard reduction and increase in forest growth. In some places the income from grazing can be expected to be very small indeed.

Studies in the wiregrass type at Alapaha indicate that it is possible to net from $.50 to $.75 per acre per year from grazing. This is based on an average of nearly four years of results. During this time the calf crop has averaged about 50 percent, calves have weighed 280 pounds at weaning time and were valued at $.13 per pound, and the cost of feeding the cows was $9.10 per head per year. Profits could be stepped up greatly by increasing the percentage calf crop, and at present this looks very possible. Amount of supplemental income from the switchcane type depends on the density and vigor of the forage. Grazing at Wenona produces greater income per acre than the wiregrass forage type in Georgia, but the poorer forage at Hofmann Forest in North Carolina probably produces less.

Effect of Grazing on Tree Seedling Establishment and Early Growth

In some forest types grazing can be beneficial in tree seedling establishment and early growth. This was found to be the case in the pond pine forest type at the Hofmann Forest. More than twice as many seedlings appeared on grazed areas as on similar adjacent areas that were ungrazed, and small seedlings grew from 7 to 75 percent faster on the grazed areas. In this case there was a dense growth of tall grass and shrubs under the old trees. Trampling by the cattle opened up the litter and rough on the forest floor, thus helping the pine seed to reach the soil. And, by removing herbaceous foliage, grazing reduced the competition to the small tree seedlings, allowing them to increase their rate of growth. The studies have not continued long enough to determine the final result.

Grazing to Reduce Hardwood Competition

Hardwoods are more palatable than pines, and this makes it possible that grazing may be a practical means of controlling undesirable invasion of hardwoods into pinelands. This is being investigated, but before specific recommendations can be offered more research is needed to explore this application of grazing as a silvicultural tool.

Grazing Reduces Fire Hazard

Cattle have real value in forest fire protection as they reduce the fire hazard by eating forage plants which comprise part of the highly inflammable ground cover. While this removal is not the only way cattle reduce fire hazard, it is one of the most important and easily seen. The difference in amount of combustible material on grazed and ungrazed areas is shown in the following table 1.

Table 1. -- Pounds of combustible material per acre on grazed and ungrazed areas (oven dry weight)

Years of Accumulation	Grazed Areas	Ungrazed Areas
1 year	1700	2390
2 years	1920	3740
3 years	2660	4510
10 years or more	3690	4500

Range Burning

In the wiregrass type: The nutritional value of wiregrass forage is very low as shown by chemical analyses. This can be improved by burning the range during the winter months. The improvement in quality is indicated in table 2. This is mainly in early spring. In addition to improving quality, however, the new fresh forage on burned areas is easier to graze and is more abundant than that on unburned range where the old growth accumulates and tends to smother out the new forage.

Table 2. -- Percentage of crude protein, calcium, and phosphorus in forage from burned and unburned range (2½-year average)

	April 1	July 21	Oct. 15
CRUDE PROTEIN			
Burned Range --------	9.2	6.2	4.6
Unburned Range ------	3.8	5.7	4.7
CALCIUM			
Burned Range --------	.13	.15	.16
Unburned Range ------	.16	.15	.13
PHOSPHORUS			
Burned Range --------	.13	.08	.06
Unburned Range ------	.05	.08	.05

That cattle on wiregrass forage make better gains on burned than unburned range is shown in table 3.

Table 3. -- Gains or losses in weight of steers on burned range compared with those on unburned range

Range Condition	Gain or loss per head per year (pounds)				
	1943	1944	1945	1946	Average
Burned Range	43.6	82.9	65.8	79.9	68.0
Unburned Range	-1.2	43.2	20.1	33.0	23.8

In the Switchcane Type: Burning switchcane areas to improve grazing was found to be inadvisable for the following reasons: (1) delays the grazing season one to four weeks, (2) causes the reeds to be more easily damaged by heavy grazing, (3) makes the foliage less frost-resistant in the fall so that the leaves drop earlier, and (4) reduces the amount of forage available for grazing. There might be an exception to the conclusion above. Where brush is invading and the range can be protected for a full growing season following burning, it might be advisable to burn to reduce brush competition. This seems to be effective because switchcane grows out faster than brushy species.

Range Improvement

Studies were started only last year to test the advantages of planting better forage species on piney woods ranges. The specific objective of these studies is the improvement of forage values and the resulting grazing capacity of wooded areas. This is to be obtained through: (1) Introduction, improvement, development and seed increase of better grasses, legumes, and other forage plants suitable for reseeding forest range; (2) the determination of their adaptation to such lands; (3) the formulation of practical methods and their establishment on forest areas; and (4) once satisfactory stands are established, determination of better methods of management. Although the studies have not gone far enough yet to draw any final conclusions, some of the better species are showing definite promise of establishment on forest range.

FOREST UTILIZATION SERVICE, 1945-1946[1]

The object of the Forest Utilization Service is to make better use of our timber resources for the ultimate benefit of the public. This aim can be achieved by reducing waste, by diversifying and improving the uses of the less-favored species, and by improving techniques or developing new ones. The field is a broad one. It includes all products and processes utilizing wood as a raw material, from fuelwood and rough-sawn lumber to paper, furniture and wood-base plastics.

The need for research in forest utilization is apparent. The large piles of sawdust, slabs, and waste wood at manufacturing plants, and the tops, limbs, and cull trees in the woods are visual testimonials of the waste in processing forest products. Prominent in our deteriorated timber stands are the large number of trees which have never been used because we have not learned to use them profitably. These trees should be utilized, if for no other reason than to get them out of the woods so the more valuable species can grow. New and improved processes and techniques for harvesting or further manufacturing the raw materials will reduce the cost of producing the finished product and thereby benefit the ultimate consumer, the public. Generally improved utilization cannot be achieved without an economic incentive. The thousands of small wood-using enterprises are in greatest need of improved utilization.

Early in its research work the Forest Service concentrated all research relating to forest products at the Forest Products Laboratory in Madison, Wisconsin. The Laboratory's record of achievement over the years has demonstrated the wisdom of concentrating at one institution the equipment and the experienced technicians in all fields of forest products research. The weakness in this segregation of research was the infrequent and inadequate contact between the researchers on the one hand and the wood-using industries as well as experiment stations on the other. As a result, the needs of the industries were not fully met, and the experiment stations could not integrate adequately their research on forest production with that of the Laboratory on forest utilization. To fill this gap, a unit of the Forest Utilization Service was established at the Appalachian Forest Experiment Station in October 1945.

The Forest Utilization Service functions through existing agencies or organizations. Its men serve as field representatives of the Forest Products Laboratory. They transmit research results to the industries, and analyze the problems of the industries in the region to discover those in need of further research. These are submitted to the Forest Products

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[1] Prepared by R. A. Hertzler; in charge, Forest Utilization Service, Southeastern Forest Experiment Station.

Laboratory or to other competent research agencies for solution. If action other than research is required to improve utilization, the men draft programs, prepare technical information, and stimulate and coordinate the activities of all existing agencies who can aid in achieving the objectives. The Forest Utilization Service also participates in pilot plant experiments and in other investigations or tests to a limited degree.

Activities in 1946

As this is a new line of work at the Appalachian Forest Experiment Station, there are no accomplishments for the 25-year period. During the first year, the two technicians of the Forest Utilization Service emphasized the analysis of regional problems, but they also made progress in several other activities.

Problem Analysis

Within the territory of the Experiment Station, what are the most important problems in forest utilization? Why are they important? What can we do to aid in their solution? Who is to take the required action? These questions must be answered for any intelligent, effective program of action to improve the utilization of the raw materials of our forests. During 1946 several investigations were made as part of this problem analysis; some of techniques or processes common to many industries, others of industries using many processes. Technicians of the Forest Products Laboratory assisted in most of the investigations.

A survey of small sawmills in the southern Appalachian mountains revealed that about one-half the mills visited were producing inaccurately sized lumber, one-third were wasting material unnecessarily, and about nine-tenths were using their equipment or labor inefficiently. One of the most important results of this short survey was that it directed attention to the need for a more comprehensive research program of the small business enterprise common to the wood-using industries.

An investigation of the current seasoning practices of the wood-using industries disclosed many needed improvements. Although the data have not been analyzed, preliminary observations are that improvements in seasoning lumber will be one of the major activities of the Forest Utilization Service for some years to come. Many plants are using kiln-drying practices that are especially wasteful of lumber.

A survey covering most of the pulp and paper mills in the Station's territory revealed that this industry expects to use more hardwoods in the future, but that it needs additional technical information on the pulping of hardwoods. The findings of this survey helped the Forest Products Laboratory formulate its research program to best serve the industry.

Current glues and gluing practices in the furniture industry were investigated. The shortage of animal glues caused many manufacturers to use polyvinal emulsions as adhesives for furniture joints. This in turn raised many problems requiring further research on these adhesives. Results of the survey also revealed the need for additional researches on the characteristics of cold-setting urea-formaldehyde glues. Research along these lines is now part of the Laboratory's program.

Utilization of Wood as Fuel for Curing Tobacco

The flue-curing of tobacco requires approximately 2 million cords of fuelwood annually. Potentially, this much fuelwood provides a splendid opportunity for thinning farm wood lots, thus improving the value of the farmer's stand of timber and also utilizing low-grade and cull trees. But the farmer, with his antiquated furnace, has difficulty controlling curing temperatures. Furthermore, he must stoke his furnace with wood most of the night. To retain this use for thinnings and cull trees, a modern, self-feeding furnace was designed and tested. This furnace operates on the slow-combustion principle and has a hopper with a fuel capacity large enough to hold the required temperatures overnight. Six separate cures of tobacco made with this furnace demonstrated its feasibility and encouraged further research to make it practical for general use. In this work the Forest Utilization Service cooperated with the Forest Products Laboratory, the North Carolina Agricultural Experiment Station, and the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Guided Expansion of Small Wood-Using Industries

Two reports were prepared to assist the State of North Carolina in its new program to develop rural industries throughout the State. One, "Opportunities for Small Forest Industries in North Carolina," describes the forest resources of the State; the timber growth and drain; the opportunities for using waste material, cull trees, and little-used species; present industries; stimulants needed for the intelligent use of forest resources; and recommendations for an action program. This report was submitted to the State for publication. The other was printed by the State as "Resource-Industry Series No. 1, The Preservative Treatment of Fence Posts." The demand for this bulletin -- approximately 4,000 copies -- provided much of the impetus needed for the initial success of the program. As a result of the bulletin four plants are now in operation, four under construction and at least thirty under consideration. The Station further assisted the program by providing a speaker for regional meetings on rural industries.

Improved Seasoning Practices

An effective beginning in the program to improve seasoning practices was the training of 110 dry-kiln operators in a course on the "Kiln Drying of Lumber." The men of the Forest Utilization Service arranged four sessions of this course, sponsored by the Southern Furniture Manufacturers' Association and conducted by technicians of the Forest Products Laboratory. Representatives of about 70 furniture manufacturers attended the course. The instructors inspected the seasoning facilities at about 25 plants and made detailed recommendations for improving practices, many of which have since been put into effect.

In cooperation with the Forest Products Laboratory a much improved process for seasoning smoking-pipe blocks was developed in an attempt to reduce waste and improve the quality of pipes made from laurel and rhododendron burls.

Better Utilization of Wood for Special Products

In conformance with the objectives of diversifying the use of species and of reducing waste, investigations were started on the use of staypak instead of specialty species for picker sticks, shuttles, and bows and arrows. Staypak was found satisfactory for picker sticks, a specialty product ordinarily made of high-quality hickory, which is becoming increasingly scarce. Sample shuttles made of staypak proved satisfactory to textile manufacturers during tests under service conditions. In view of the scarcity of dogwood, the usual material for shuttles, the commercial production of staypak shuttles is feasible. Bows and arrows made of staypak were found to have several advantages over those made of the species of wood ordinarily used. There are possibilities of producing them on a commercial scale. An industrial floor constructed of cedar elm in a textile mill compares favorably with the standard maple floor adjacent to it.

Technical Advice and Guidance

One of the most important activities of the Forest Utilization Service is to provide advice and guidance to the wood-using industries of the Region, especially operators who cannot employ adequate technical help. During 1946, several hundred requests for technical information were answered in person, by correspondence, or by referring the inquiry to the Forest Products Laboratory. As an example, advice and information were given to the owner of a small woodworking plant who was forced by market conditions to abandon the manufacture of smoking pipes. As a result, the plant was converted into a hickory dimension mill and is now thriving. Advice and technical guidance were given representatives of colleges, research institutions, federal, state, and other government agencies, as well as industries, regarding plans, programs, and other aspects of forest utilization. Suggestions for research at the Forest Products Laboratory were given during the

Laboratory's annual program conference. The results of this type of continuous work are difficult to evaluate but it is known to have improved utilization, stimulated further research, and aroused a consciousness of better forest utilization.

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